The "Coal" article from The World Book Encyclopedia was prepared with the cooperation of the National Coal Association. It was written by Wilbert G. Fritz, M.B.A., Formerly, Consultant on Materials, Office of Defense Mobilization, Executive Office of the President, Washington, D.C. and was critically reviewed by M. Edmund Speare, Ph. D., Educational Director, National Coal Association.

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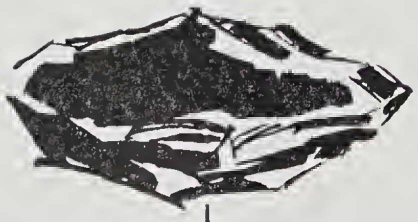

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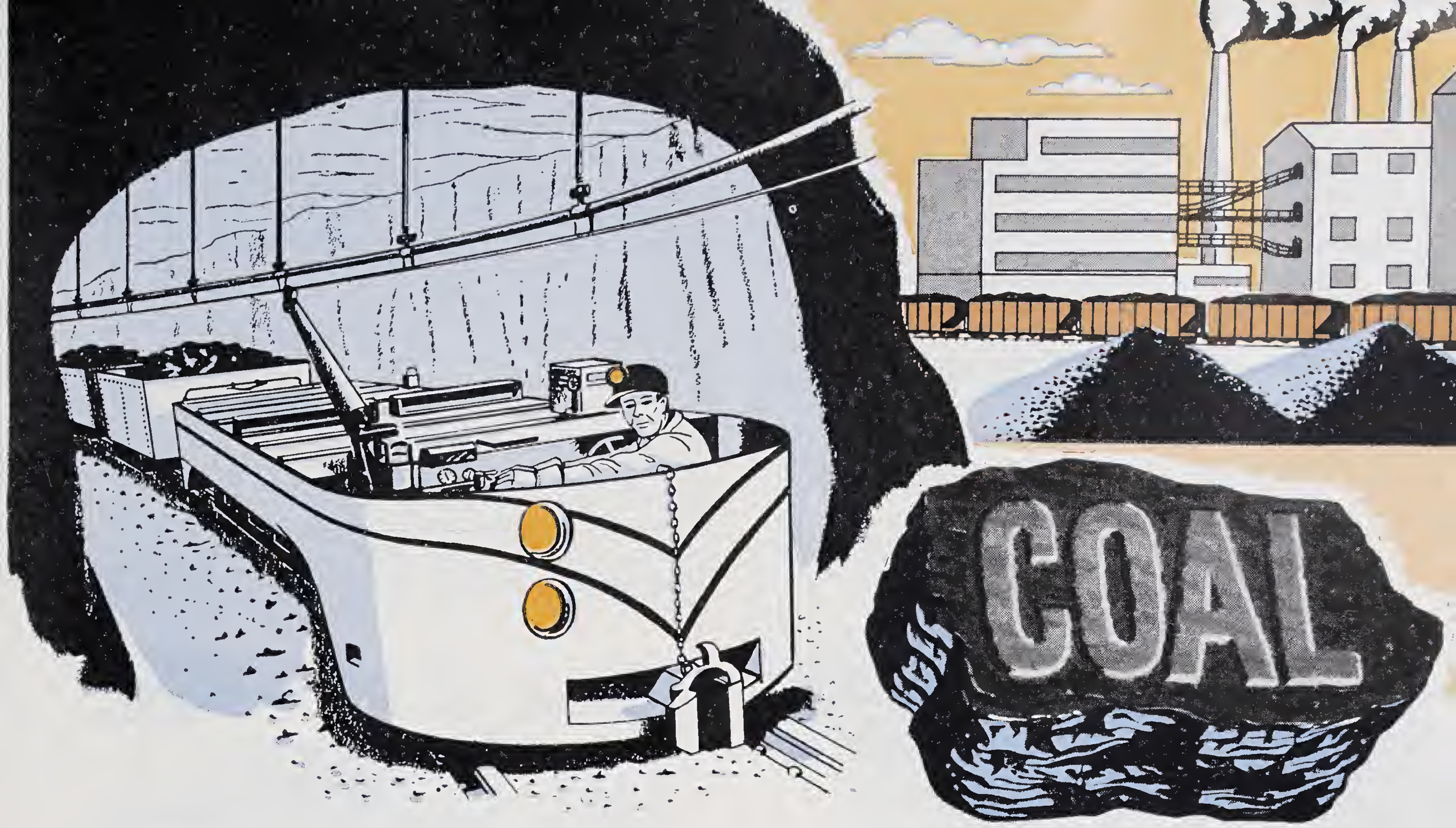


COAL is a soft, black or brown rock. Because coal is one of the most useful rocks dug from the ground, it often is called the *black diamond*, or the *magic mineral*. Coal can be burned to heat homes and buildings. It can heat water into steam to run factories or to manufacture electricity. It can be made into gas to cook food. Coal is used with iron ore in making almost all iron and steel. Hundreds of chemical products can be made from coal, such as perfumes, plastic phonograph records, nylon stockings, aspirin, artificial rubber tires, and beautiful dyes to color clothes.

Another name for coal is *buried sunshine*. This is because coal captured the sunlight that fell on ancient forests long before there were men on the earth. When we burn coal, we are using this energy from the sun.

Coal is one of the most important sources of energy for our modern civilization. In the United States, coal supplies almost as much power and heat as do all the other sources of energy combined. Coal furnishes an even larger share of energy in other industrial countries.

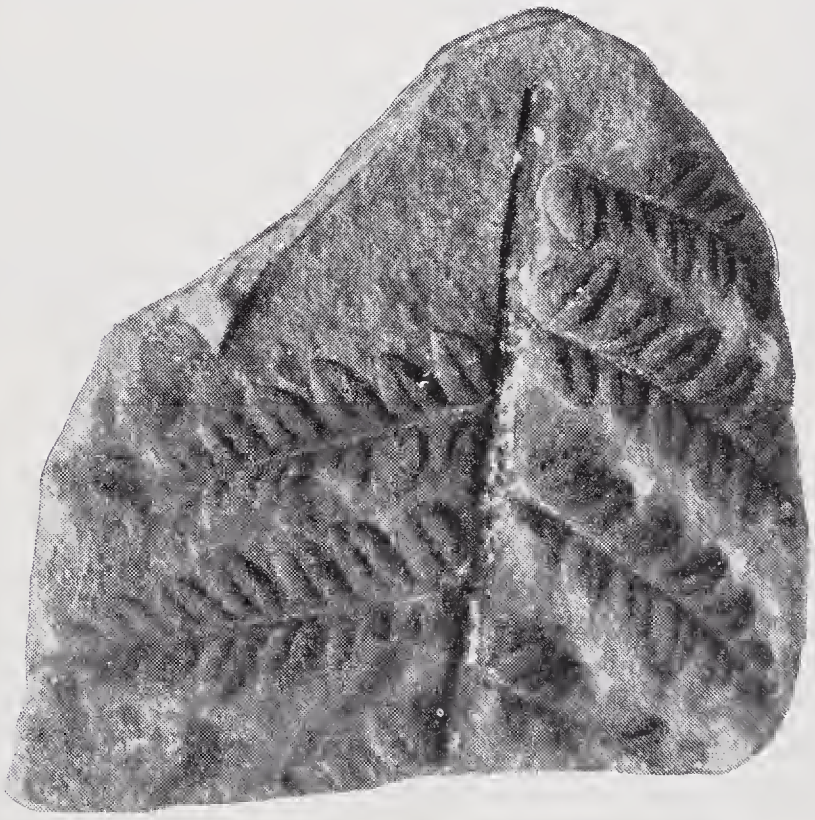
How Coal Was Formed

A chunk of coal looks black and smooth. But if you look at a piece of coal under a microscope you will see that it is red and gold in color. Look closely at the coal and you may be able to see the markings of plants and ferns on it. These are the plants from which coal was formed. See accompanying illustrations, showing a fern fossil and the way coal was formed.

Time of Formation. Some coal was formed 400,000,000 years ago. But most high-grade coal, such as that found in Pennsylvania, was formed about 250,000,000 years ago, during a time called the *Carboniferous Period*. (See Geology [Outline of Earth History].) Some coal is being formed in small quantities even now.

During the time that most coal was formed, the air was damp and steamy. Most of the plants were strange-looking ferns and trees that had no flowers. As these plants died, others grew on top of the old ones. This happened time after time for thousands of years. The rotted plants turned into a substance called *peat*, which looks like tightly packed rotted wood. After a while, wide areas of the earth's surface sank. Streams and oceans poured in, carrying mud and sand which covered the peat. The pressure of the water above squeezed down the mass of peat and gradually formed it into coal. The greater the pressure, the higher the grade of coal that was formed. Geologists have estimated that a thickness of from five to eight feet of rotted plants and ferns was needed to form one foot of coal.

Geologists have two main theories to explain how rotted plants piled up in layers thick enough to produce thick beds of coal: (1) the plants grew and died in swamps, piling up layer after layer; (2) the rotting plants were carried by streams and deposited in certain areas.



Chicago Natural History Museum

A Fern Fossil. The plants that helped to form coal ranged from delicate mosses, ferns, and rushes to the largest trees. On this lump of coal may be seen a fragment of a fern.

Most geologists believe that the first theory is the correct one.

Coal Beds. Deposits of coal vary in thickness from a few inches to several hundred feet. Most coal is mined from beds which are from two and one-half to eight feet thick. These deposits are sometimes called *seams*, or veins, but geologists prefer to use the word *bed*, because coal was formed in wide bedding areas. Coal deposits are sandwiched between layers of rock and dirt. The deposits may be level, sloping, or tipped on end, depending on whether they have been affected by the cracking and folding of the earth's crust. Many of the deposits in the mountain sections of eastern Pennsylvania are tilted at various angles.

Coal beds may lie deep in the ground or near the surface. In hilly or mountainous country, the coal is often on the surface. But it is likely to be covered with dirt or so weathered from exposure to the air as to be hard to recognize. Excavations for buildings, railroads, or highways frequently uncover coal beds. Such beds are sometimes found in drilling for water, oil, or gas. But the principal method of locating coal is to use core drillings. This is done by drilling out a *core*, or column, from the earth's crust to indicate, layer by layer, what is under ground.

HOW COAL WAS FORMED

1. Dense Forests and Swamps covered much of the earth's surface hundreds of millions of years ago. They were filled with strange-looking trees, giant rushes, and wide-spreading ferns. Among the plants lived big lizards and giant insects.

Chief Kinds of Coal

The plants which became coal took from the air the carbon they needed for their growth. They used a process made possible by sunlight. When the plants were squeezed together by water pressure, large amounts of oxygen and hydrogen were driven out, while the carbon remained. Because coal has no fixed chemical formula, geologists classify it merely as a sedimentary rock.

Coal usually is divided into two main classes—*anthracite*, or "hard" coal, and *bituminous*, or "soft" coal. When anthracite was formed, it was squeezed under greater pressure than was bituminous. As a result, anthracite contains the highest percentage of carbon and the lowest percentage of moisture. Anthracite makes up only a small part of the world's supply of coal. About half of the world's coal reserve is bituminous coal. The rest is still softer coal, called *subbituminous* coal, which is less valuable than bituminous coal.

Anthracite generally lies deeper in the earth than bituminous. Nearly all the anthracite in the United States is found in eastern Pennsylvania. Small beds of this hard coal are also located in Arkansas, Colorado, New Mexico, and Virginia. Most of it is used as a fuel for household heating systems. Anthracite burns with almost no smoke. It sells for a higher price than bituminous coal, although the heating value of anthracite is slightly less than that of the better grades of bituminous coal.

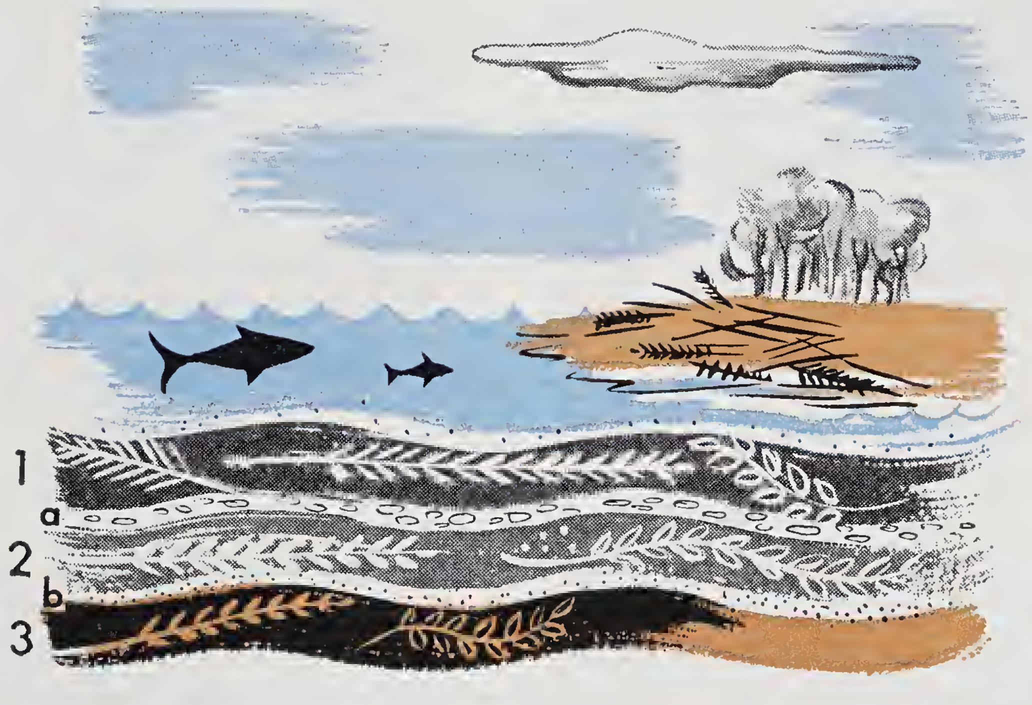
Bituminous Coal is the most important and the most plentiful grade of coal. It is used for heating homes and buildings, and is also used for making gas, coke, and various chemical by-products of coal. *Coking coals* are bituminous coals that will readily melt, or *fuse*, in a retort or oven. *Steam coals* are used in heating plants and steam-generating plants. *Coke* from coking coals is used in foundries and blast furnaces, as well as for home heating. So-called *gas coal* is any coal which is used for making gas.

2. As the Giant Plants Died, they fell into the swamps. The dead trees and ferns became tangled in a mass of decayed vegetable matter. This spongy, brown vegetable matter is called *peat*, the first material in the formation of coal.

Large deposits of bituminous coal are found in many states of the Union, both east and west of the Mississippi River. The most important bituminous coal beds in the United States are located in an area west of the Appalachian Mountains, from Ohio and Pennsylvania southwest to Alabama. About three of every four tons of bituminous coal mined in the United States each year comes from this rich eastern bituminous area.

Subbituminous Coal contains about 25 per cent moisture. It burns readily, and can be used for household heating and for industrial plants. It is not so good a fuel as bituminous coal, because it contains so much moisture. Wyoming has almost four fifths of the subbituminous coal in the United States. Other important deposits of subbituminous coal are found in western states, including Colorado, Montana, Washington, and Utah.

Other Kinds of Coal which have limited uses are soft varieties which contain less carbon and more moisture than the commercial grades. *Brown coal* and *lignite* are brownish-black coals which contain about one half water. Lignite is the harder type of brown coal. Large deposits of lignite are located in the northwestern United States and in western Canada. *Peat* is one of the earliest stages of coal. The remains of plants and ferns which have been preserved may be clearly seen in peat, which contains about 90 per cent water. Peat has been used as a fuel for hundreds of years in Ireland, England, and Germany. *Cannel coal* is a type of coal which is formed from the seeds and spores of plants rather than the wood, bark, and leaves. This curious variety of coal may be lighted by a match, and burns with a long, bright flame almost like that of a tallow candle. It is often used in fireplaces, camping stoves, and outdoor cooking grills.



3. New Plants Grew on Top of the Old. Then they, too, died and became part of the mass of peat. Water sometimes covered the area. Different thicknesses (*1, 2, 3*) were caused by dirt and sand (*a, b*) being deposited between layers of peat.

How Coal Is Mined

Types of Mines. There are four general types of mines: shaft, drift, slope, and strip. Each type of mine is particularly suited to a different kind of coal bed. When coal beds were first being formed of peat, they were as flat and level as swamps. Later, however, changes in the earth's crust pushed some beds into folds, much as a piece of paper can be crumpled in the hand. Other beds became tilted, and some of them stand nearly on end. Streams cut along the sides of hills and exposed many coal beds near the surface of the ground. It takes different types of mines to reach these various kinds of coal beds.

Shaft mines are dug to reach coal beds lying far below the earth's surface. The coal is brought to the surface by an elevator system. Separate shafts are often dug to provide ventilation for the working rooms far beneath the ground. The average depth of shaft mines in the United States is 260 feet.

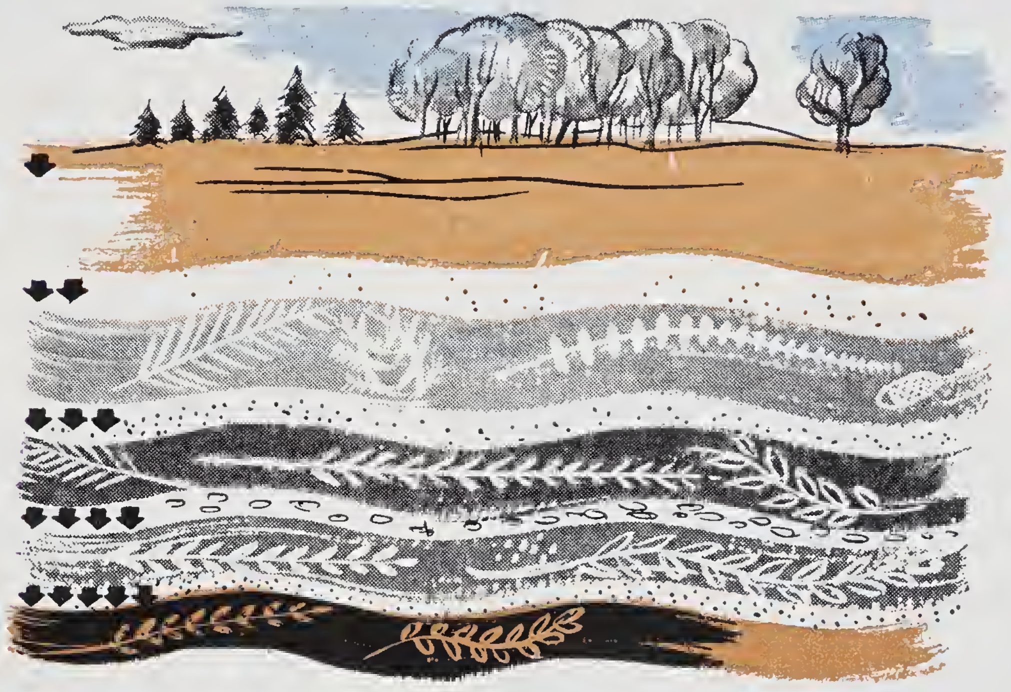
Drift mines are used to reach coal beds in hillsides. The mine entrance is located where the coal is exposed, and the mine tunnel is dug farther and farther back into the bed of coal.

Slope mines are used in coal beds which lie near the surface of the earth. The tunnel is sloped gradually downward through the ground until it reaches the level of the coal bed.

Strip mines, or *open-pit mines*, are located over coal beds which lie quite near the earth's surface. In many strip mines, the coal can be dug from the face of the bed by power shovels after the ground layer of dirt and rocks has been removed. This layer of earth and rock covering the coal bed is called the *overburden.*

Three out of every five coal mines in the United States are either drift mines or slope mines. Shaft mines are the most common type in Illinois and Indiana, because there are few valleys deep enough to expose the coal beds.

Mining Systems. Coal is mined according to a definite plan. The planning begins at the point where the coal bed is reached by the shaft or tunnel. The coal is mined in such a way as to leave space through which the coal can be hauled.



4. Heat and Pressure (↓) of water, dirt, and sand on top the peat caused different types of coal to be formed. Where the pressure was the greatest, the soft coal (bituminous) was squeezed into the hardest grade of coal (anthracite).

The wall of the bed from which the coal is taken is called the *mine face.* In cutting into this mine face, there are two general mining systems: (1) the room-and-pillar system, and (2) the longwall system.

Room-and-pillar mines are composed of a series of rooms cut into the coal bed. Columns, or *pillars*, of coal are left standing to support the roof. These mines are cheap to operate. Most coal mines in the United States are of this type. A disadvantage is that the coal left in the pillars is wasted. But in the more valuable American coal mines, the pillars are taken out as soon as all other coal has been mined from the room. This removal is called the *room-and-pillar retreat* system. It permits the mining of about 95 per cent of the coal in the bed.

Longwall mines are most commonly used in England. The coal is mined along a long front, or *face.* Timbers are installed along the face to support the roof. An

Coal Age; Bituminous Coal Institute

Strip Mining. A dragline, *above,* scoops up nearly 600 cubic feet of rocks and dirt at a time—enough to fill a small room—while clearing the way to a bed of coal. A big shovel, *left,* clears away rocks and dirt as a smaller shovel loads coal into trucks.

advantage of the longwall system is that almost all the coal can be removed. But the installation of the supporting timbers is expensive.

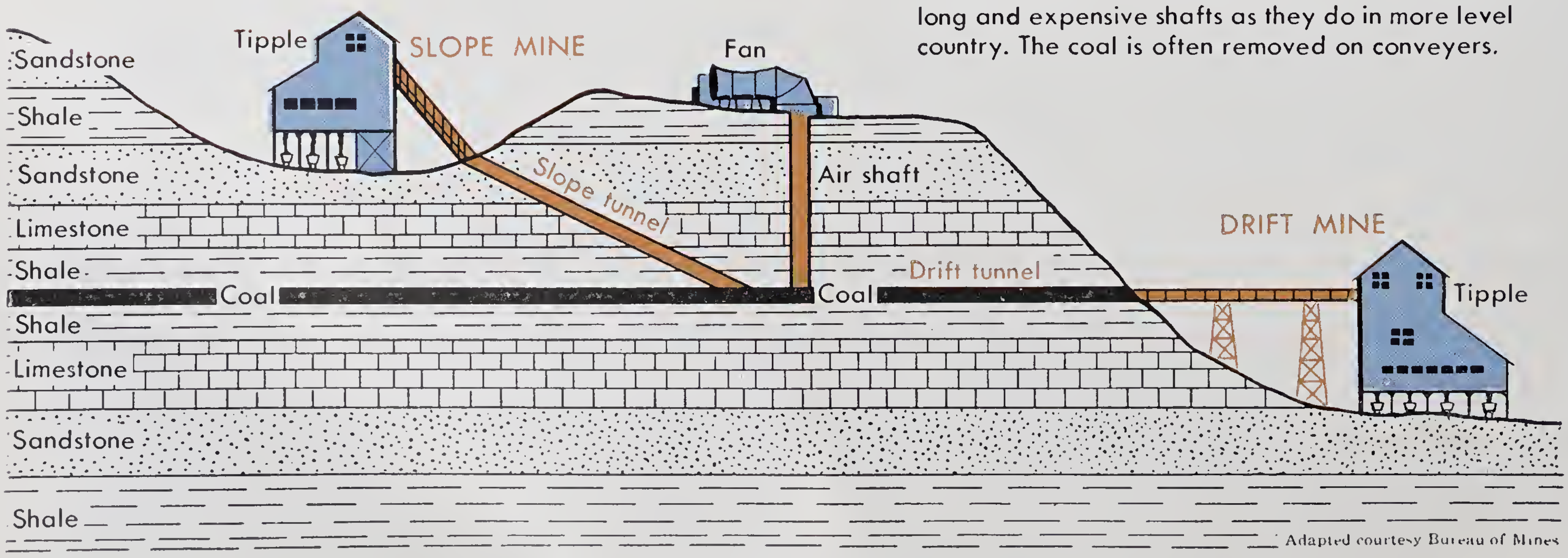
Breaking Down the Coal. There are many methods of breaking coal from the mine face in lumps suitable for hauling to the surface of the mine. The coal was once broken off by men working with picks. But in modern, mechanized mines nearly all this work is done by machinery. The slow, backbreaking hand labor of early mining methods has almost entirely disappeared in such mines.

Undercutting. Before the coal wall can be cracked by any method, the face usually is dug out near the bottom of the coal bed so the coal will fall down when it is shattered. This undercutting may be done by hand, but more than 90 per cent of the undercutting in mines of the United States is done by machines. These machines are equipped with sharp, powerful blades which tear out the coal in a wide groove, or *kerf*. Some undercutting machines are built to cut into the coal not only at the bottom, but also at the top and sides of the face. Another simple method of mining is called *shooting-off-the-solid.* The coal is blasted off the solid bed without any undercutting to help break it down. But a dangerously large explosive charge is needed in this method, and much dust and fine coal are produced.

Cracking the Coal Wall. If explosives are to be used in breaking down the coal, shot holes are drilled at intervals along the face of the coal bed. The explosives are inserted in these holes. When the explosion occurs, the coal wall cracks into pieces. Black powder was once used as the chief explosive in coal mines, but it had a tendency to set fire to the gases and dust which accumulate in coal mines. Black powder has been discarded as too dangerous. Dynamite is the most widely used explosive in present-day mining. It, too, is somewhat dangerous, and safety inspectors urge that cylinders of compressed air or liquid carbon dioxide be used instead.

SLOPE AND DRIFT MINES

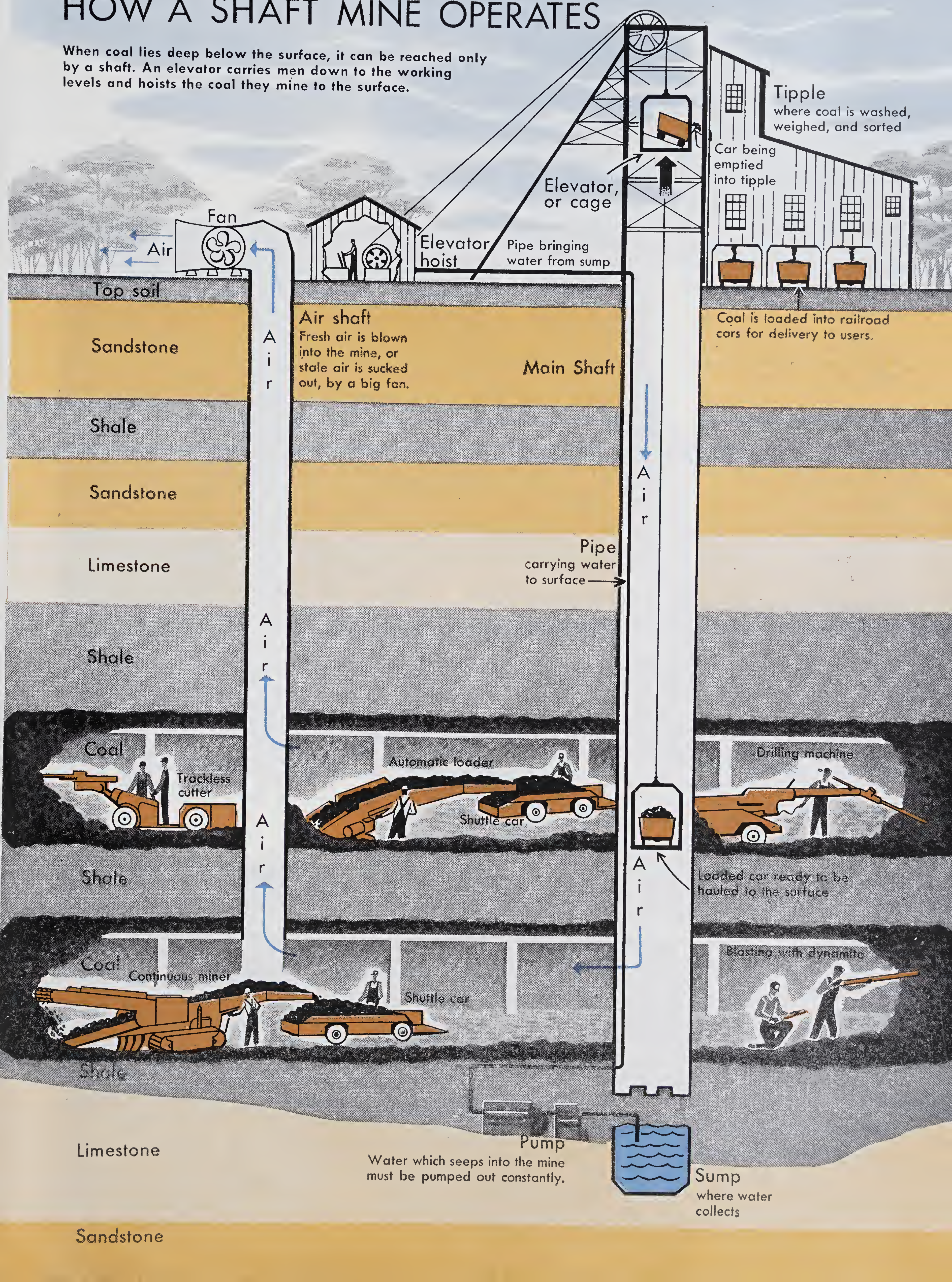
When coal is found in hilly or mountainous country, miners can dig into the layers of coal from the sides of the hills. They do not usually have to dig long and expensive shafts as they do in more level country. The coal is often removed on conveyers.



Adapted courtesy Bureau of Mines

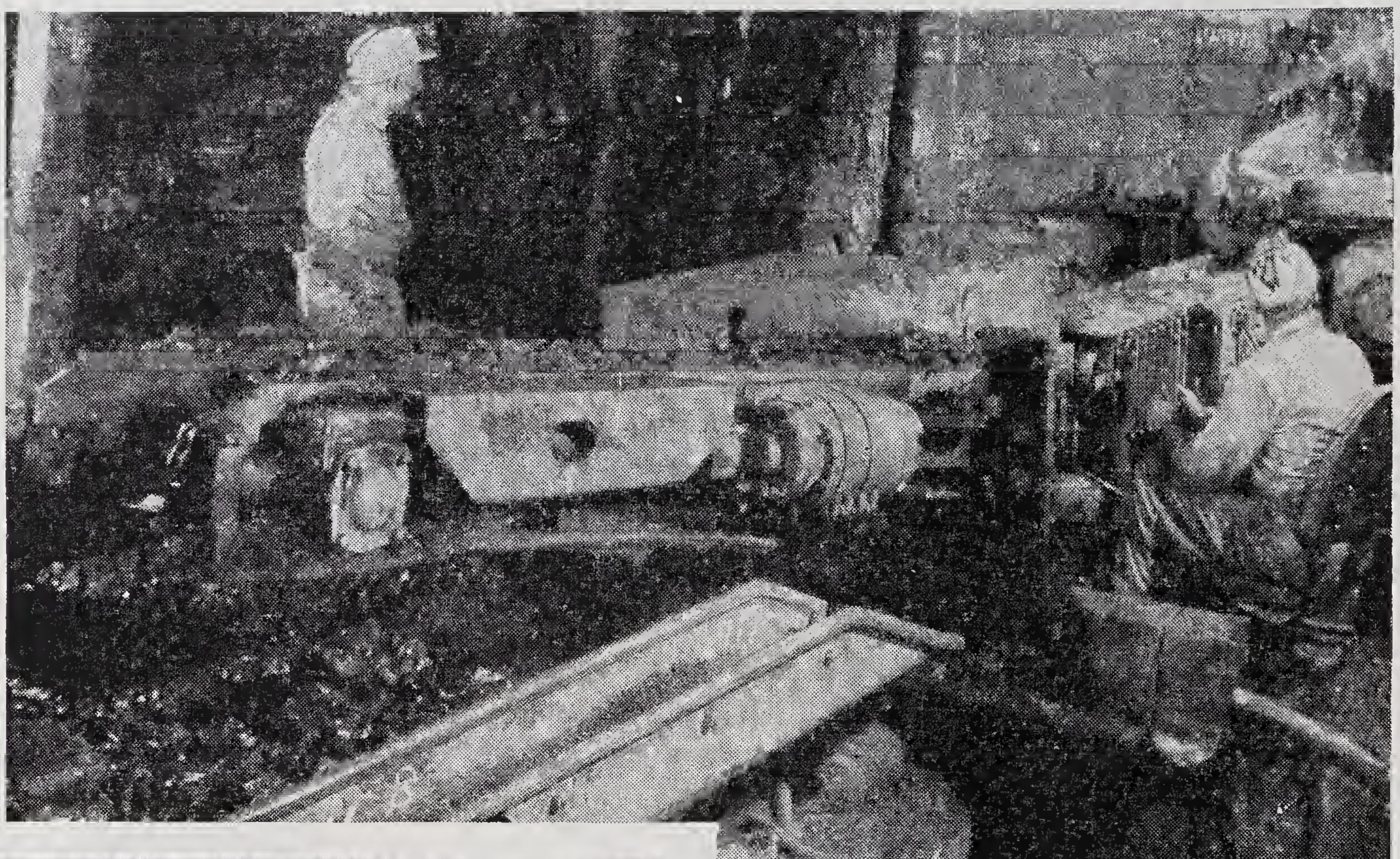
HOW A SHAFT MINE OPERATES

When coal lies deep below the surface, it can be reached only by a shaft. An elevator carries men down to the working levels and hoists the coal they mine to the surface.

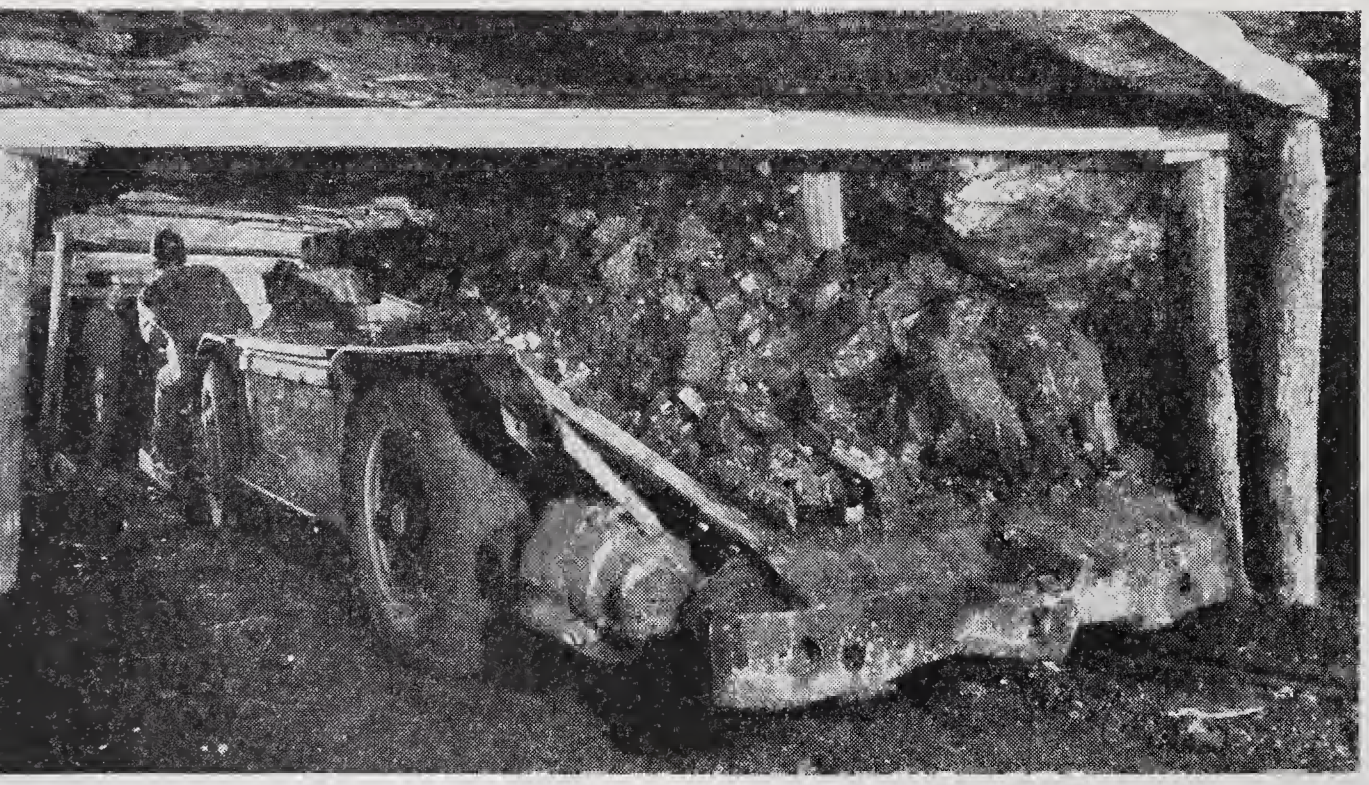

Tipple
where coal is washed, weighed, and sorted
Car being emptied into tipple
Elevator, or cage
Fan
Air
Elevator hoist
Pipe bringing water from sump
Top soil
Coal is loaded into railroad cars for delivery to users.
Sandstone
Air shaft
Fresh air is blown into the mine, or stale air is sucked out, by a big fan.
Main Shaft
Air
Shale
Sandstone
Limestone
Pipe
carrying water to surface
Shale
Coal
Trackless cutter
Automatic loader
Shuttle car
Drilling machine
Shale
Loaded car ready to be hauled to the surface
Coal
Continuous miner
Shuttle car
Blasting with dynamite
Shale
Pump
Water which seeps into the mine must be pumped out constantly.
Limestone
Sump
where water collects
Sandstone

A TRIP TO A COAL MINE

1. Continuous Miner looks like a steel dragon as it moves along a seam of coal, chewing out great chunks with its big teeth.



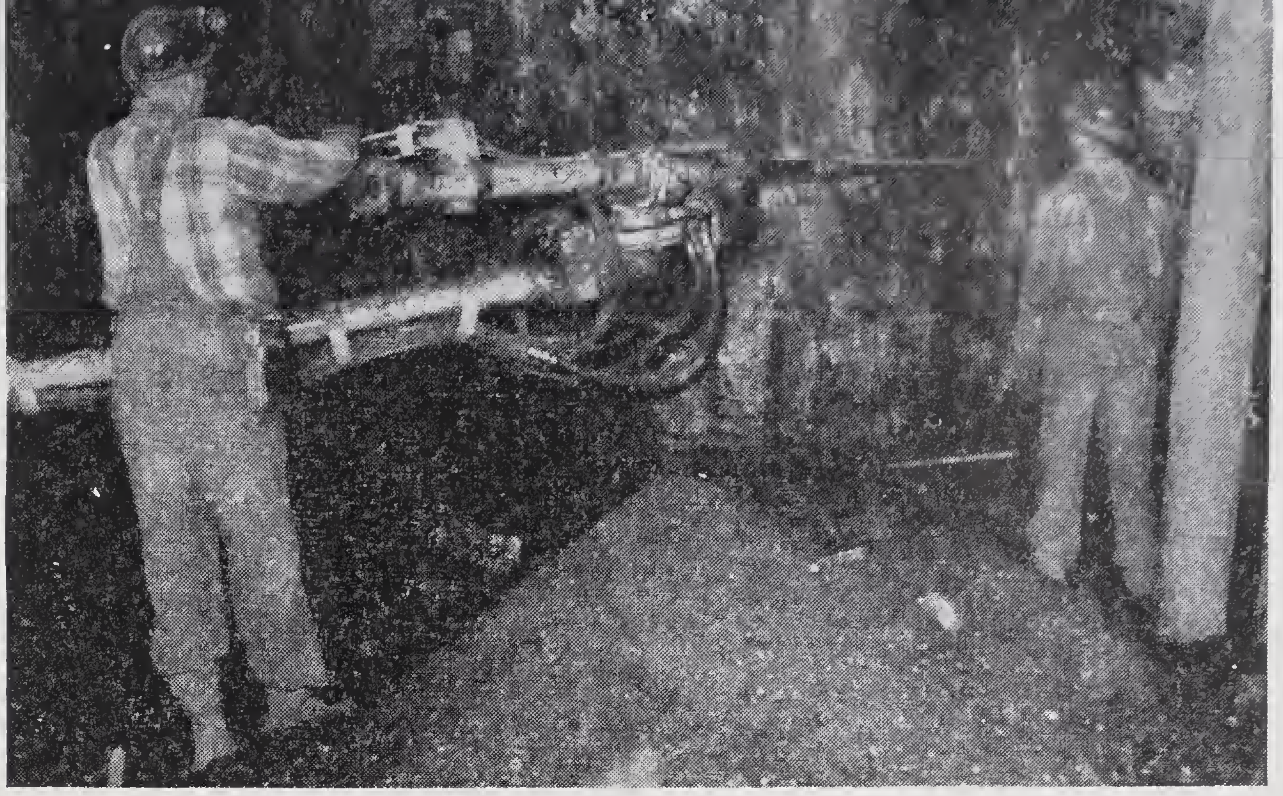
2. Back of Continuous Miner loads the chunks of coal directly into shuttle cars at 6 tons a minute.



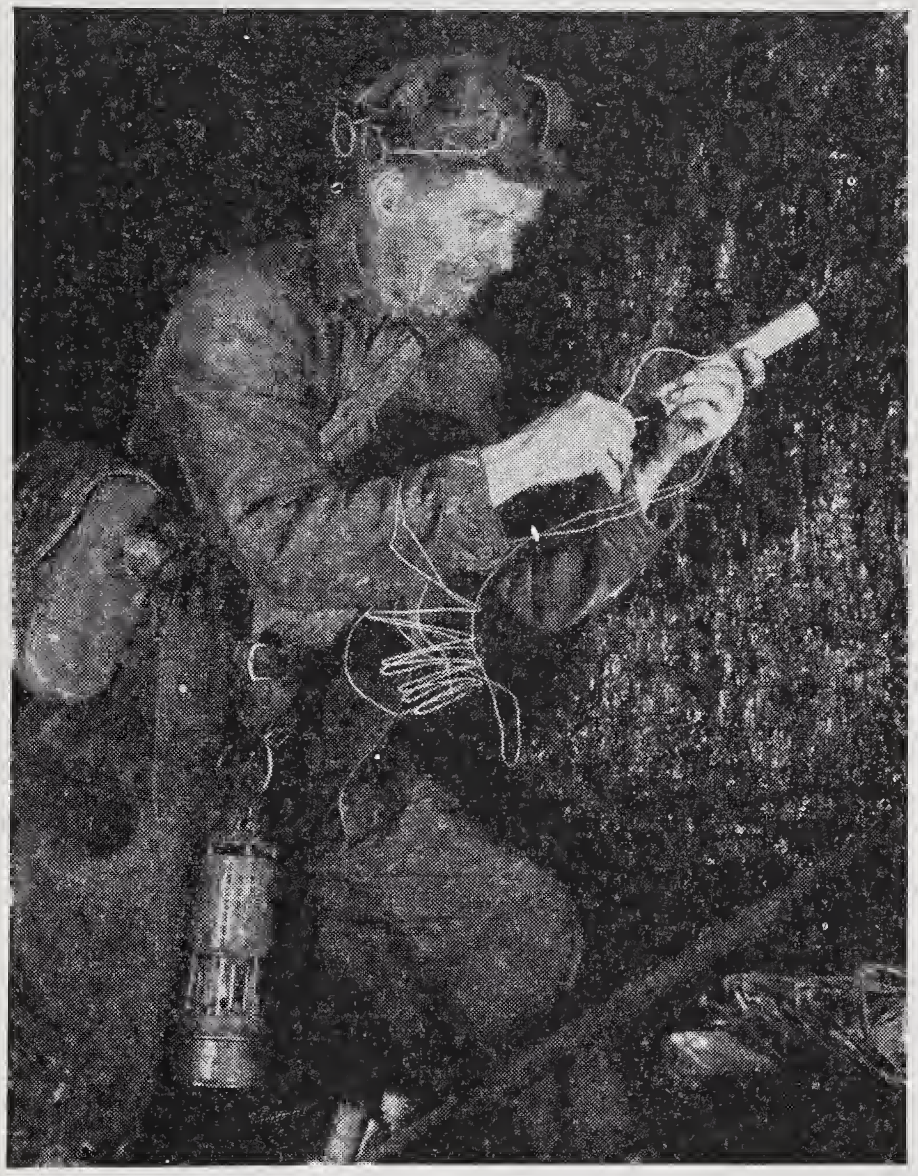
3. Shuttle Cars, or *buggies*, go back and forth between the coal miner and the elevator or conveyer which takes coal to the surface.

4. Mobile Cutting Knife is like a giant saw. By moving levers, the operator can make it slice off chunks of coal either up and down or across the seam.

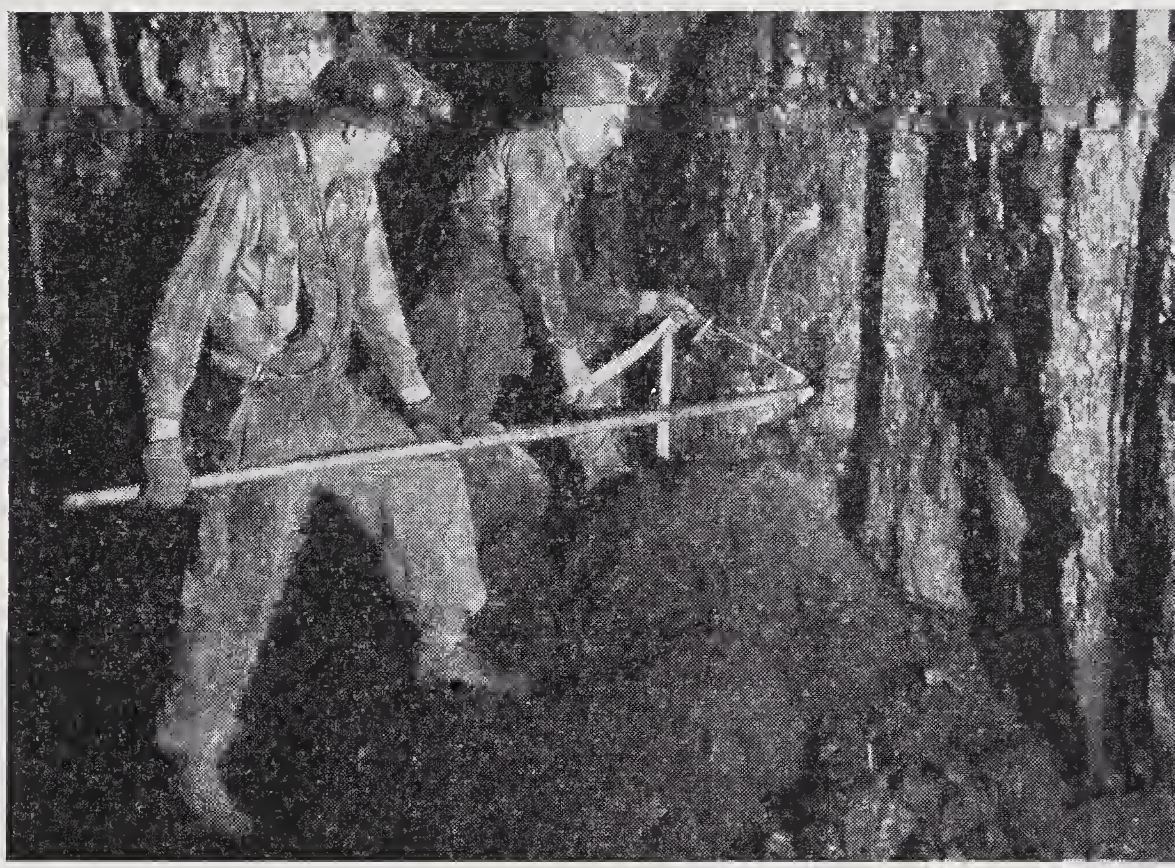
5. Electric Drill is used to bore 1½-inch holes in a coal face to hold explosive charges for blasting out chunks of coal.



6. Miner Called a Shot-Firer inserts firing mechanism into explosive cartridge before tamping it into a drilled hole.

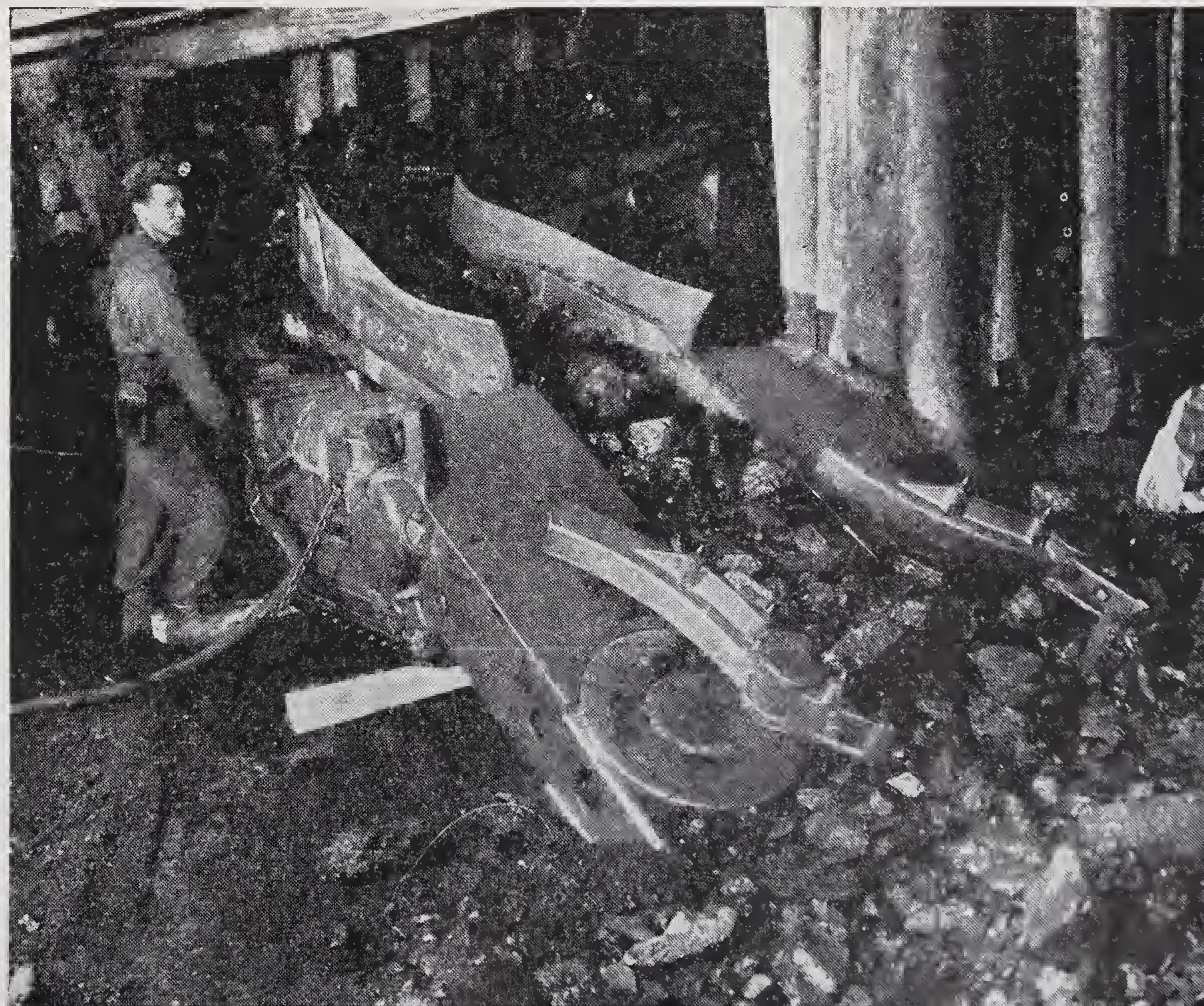


7. Explosives are placed in 14 holes across the coal face. Then the miners leave the blast area and the cartridges are exploded.



Bituminous Coal Institute: Weirton Steel Co.; Western Kentucky Coal Co.; U.S. Steel Corp

8. Crawler-Type Loader moves in to pick up the chunks of coal blasted from the coal face. It loads these into shuttle cars.



These cartridges are placed in the shot holes, and set off by an electrical charge. The air or carbon dioxide expands with such force that the coal wall is shattered as thoroughly as if dynamite had been set off. Compressed-air cartridges are much used in Great Britain.

Complete Coal-Mining Machines. Since World War II, many new machines have been developed to mine coal almost automatically. Use of these machines reduces accidents and reduces mining costs. A *continuous mining machine* can cut the coal loose and load it in one operation. Two men running this machine can mine coal at the rate of about four tons a minute. The *coal auger* is a giant bit which can drill into a coal deposit and remove the coal from the holes it makes. The holes the auger bores may be up to 52 inches across and nearly 300 feet deep. The *robot miner*, a cutting machine, mines coal near the surface without a workman underground to run it. The robot has four cutting heads on a frame. Two men working above ground can guide one type of robot into the coal bed by means of electronic devices. This robot can dig 700 feet into the side of a hill and pour out nearly 70 tons or more of coal an hour. (See illustrations of the robot miner and auger later in this article.)

Hauling Coal Out of the Mine. As rapidly as the coal is dug, tracks are laid in the tunnel, or *haulage way.* Cars loaded with coal are pulled over these tracks by small but very powerful electric locomotives, or by cables. An increasing number of mines use conveyer belts to carry the coal to the surface. In most underground mines, the loose coal is gathered up by low, flat machines which carry the coal to the mine cars or a conveyer belt. In surface mining, the loose coal is gathered up by large power shovels.

Sizing. Coal as it is taken from the mine is called *run-of-mine* coal. Pieces range in size from large chunks to a fine powder. Not much coal is sold in this *run-of-mine* form. Most of the coal is divided into various sizes by being passed through large screens. Each screen has openings of a certain size. See illustration, From Mine to Bin.

The coal is hoisted into a large building, called a *tipple* in bituminous mining and a *breaker* in anthracite mining. This is a preparation plant. Here the coal is washed and sorted, and the impurities are removed. Sometimes the coal is oiled. Especially in anthracite mining, the coal may be crushed into smaller sizes. Bituminous coal is divided into several large, or *lump*, sizes, and also into smaller sizes known as *stove*, *egg*, *nut*, *pea*, *slack*, and *pulverized* coal. Anthracite must be broken up to remove slate and other impurities embedded in it before it can be divided into sizes. Anthracite is screened into sizes called *lump*, *egg*, *stove*, *chestnut*, *pea*, *buckwheat*, and *rice*. The larger sizes of coal sell best for many heating purposes, and commonly bring higher prices than the small sizes. The increased use of stoker-fed home furnaces within recent years has provided a larger market for small sizes of coal, however.

Powdered coal is used for many industrial purposes. Sometimes this fine coal is pressed into blocks, called *briquettes*, for use in fireplaces. A binding material, such as pitch or tar, is mixed with the powdered coal to hold the briquettes together. Powdered coal is also used in industrial furnaces which are equipped to blow the coal into the firebox.

Cleaning. Anthracite usually has a large quantity of slate mixed with the coal as it leaves the mine. After being broken into smaller sizes, the anthracite is sent through mechanical cleaners which automatically remove the slate. At some mine tipples, men are employed to pick the slate out by hand as the coal passes over the chutes. In many bituminous coal mines, little or no slate is found with the coal.

Clay and other impurities found in coal are removed at the surface. Here, too, the coal is washed, or dusted, to make it cleaner for consumers to handle. Sometimes coal is treated with chemicals or sprayed with oil to settle the dust.

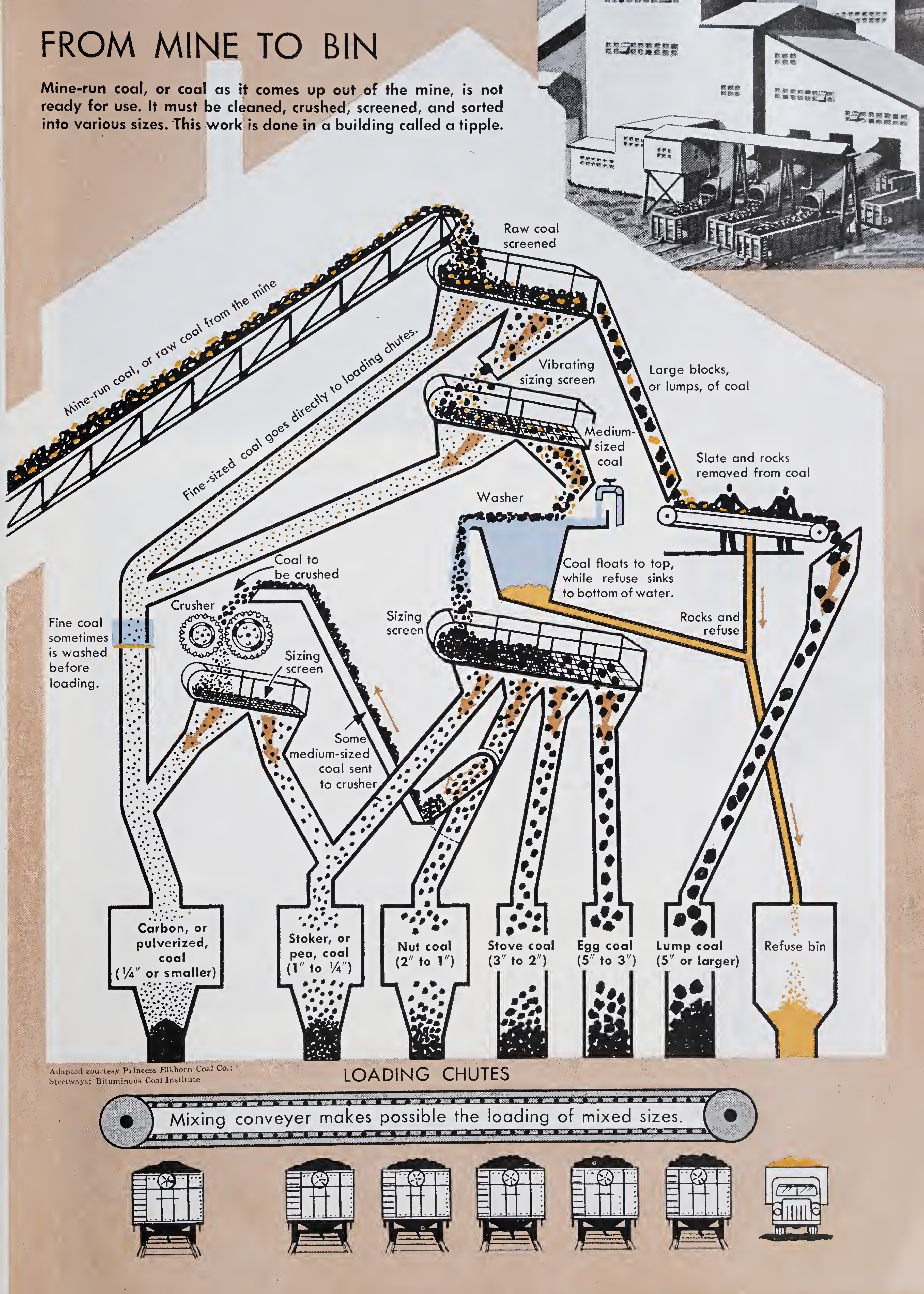
Grading. In its natural state, coal is classified by *rank*, which depends on its carbon and ash content, the amount of volatile, or gassy, matter and moisture it contains, and its heat value. As sold in the market, coal is classified by *grade*, which depends on its rank and such other characteristics as the size of the lumps and on special treatment which the coal has received. The grade of coal is of interest to customers, for it means that the coal will meet certain standards.

In Large Underground Coal Mines, Miners Ride to and from Their Work in Clean, Rapidly Moving "Man-Trip Cars"

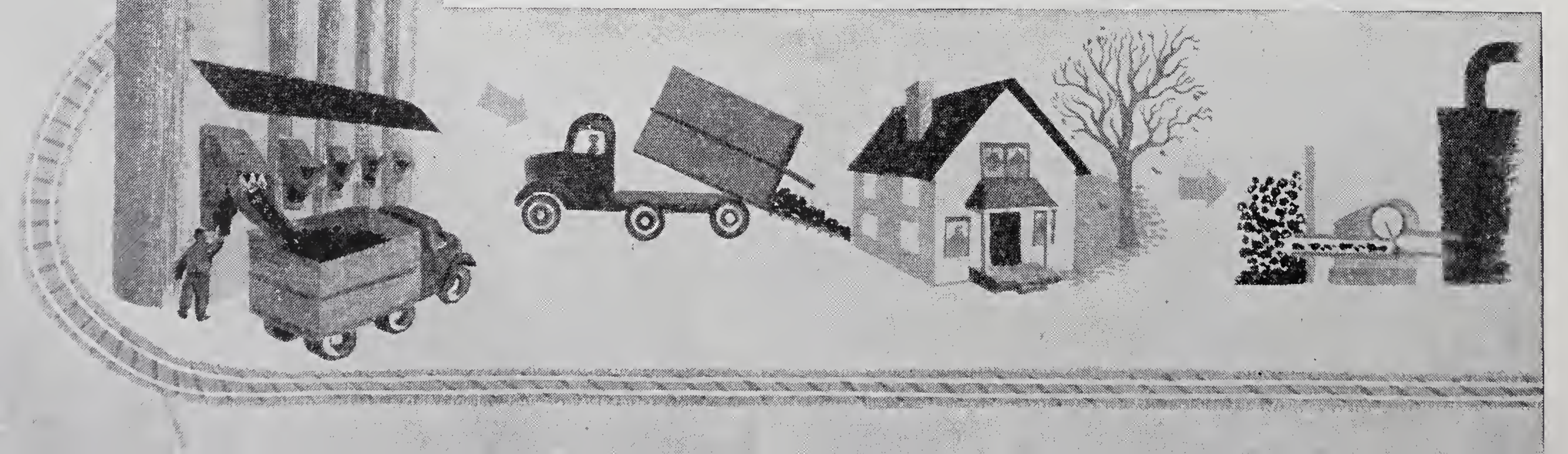
Weirton Steel Co.

FROM MINE TO BIN

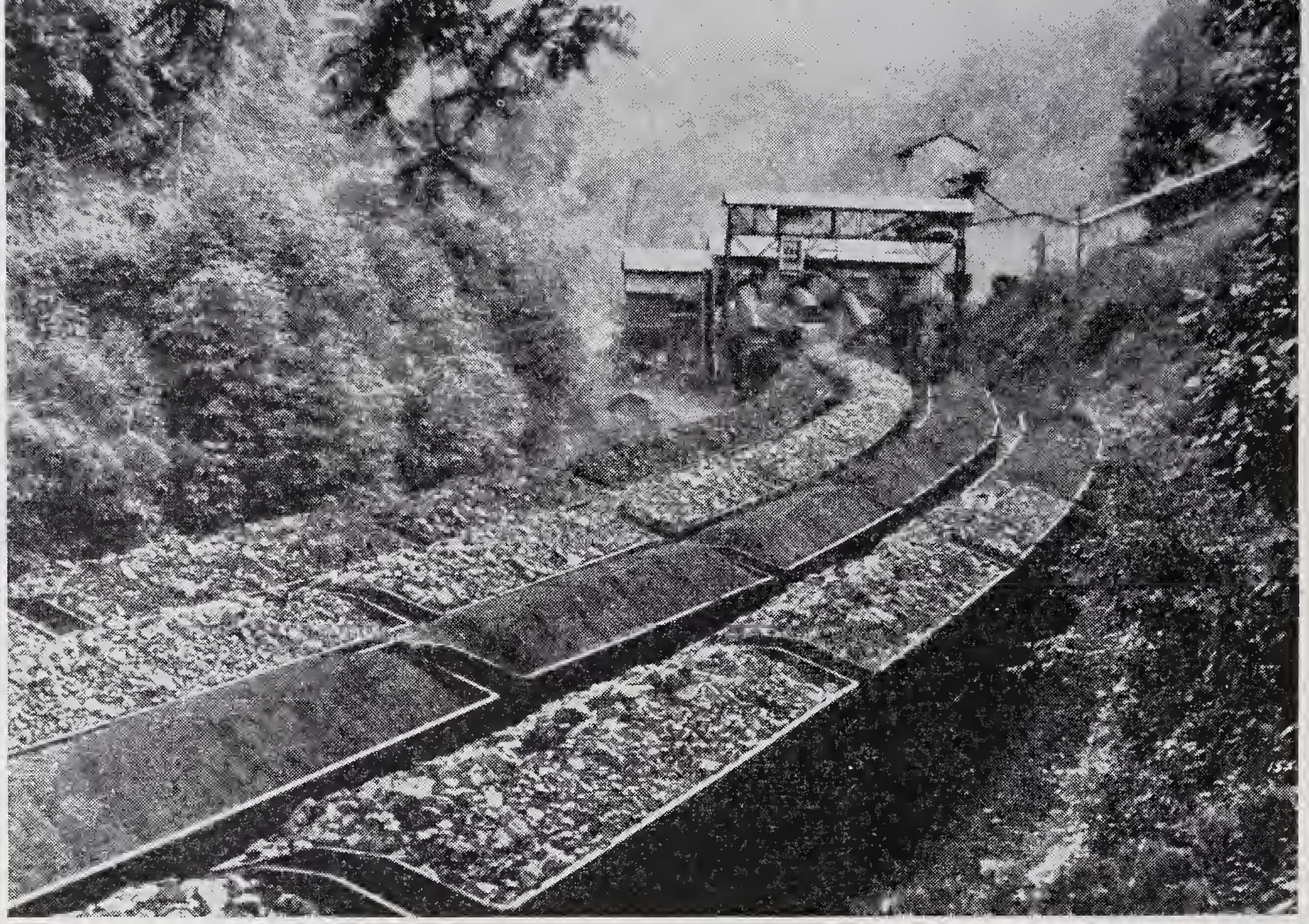
Mine-run coal, or coal as it comes up out of the mine, is not ready for use. It must be cleaned, crushed, screened, and sorted into various sizes. This work is done in a building called a tipple.


Mine-run coal, or raw coal from the mine
Raw coal screened
Fine-sized coal goes directly to loading chutes.
Vibrating sizing screen
Large blocks, or lumps, of coal
Medium-sized coal
Slate and rocks removed from coal
Washer
Coal floats to top, while refuse sinks to bottom of water.
Coal to be crushed
Crusher
Fine coal sometimes is washed before loading.
Sizing screen
Sizing screen
Rocks and refuse
Some medium-sized coal sent to crusher
Carbon, or pulverized, coal (¼″ or smaller)
Stoker, or pea, coal (1″ to ¼″)
Nut coal (2″ to 1″)
Stove coal (3″ to 2″)
Egg coal (5″ to 3″)
Lump coal (5″ or larger)
Refuse bin
LOADING CHUTES
Mixing conveyer makes possible the loading of mixed sizes.

Adapted courtesy Princess Elkhorn Coal Co.; Steelways; Bituminous Coal Institute



Transporting Coal. From the tipple, *above*, coal of various sizes slides down chutes directly into railroad cars. The railroads carry coal to retail dealers and to large users such as steel mills and electric-power plants. Along the Ohio and Mississippi rivers and other inland waterways, great quantities of coal are carried on huge barges which are towed or pushed by tugs (see picture *top right*). Ships are used to carry coal to other countries and on the Great Lakes. Trucks often deliver coal from retail dealers to homes and businesses.



Norfolk & Western Railway

How Coal Is Transported

Shipping. After the coal has been cleaned at the tipple or breaker, it is usually loaded into railroad cars or coal barges. Sometimes coal is loaded for shipping directly from the car which has brought it to the mine surface.

Coal needs heavy transportation equipment because the fuel is so heavy and bulky. In the present day, railroad cars transport about 80 per cent of the coal produced in the United States. The fuel is carried in open-topped coal cars called *gondolas*, or *hoppers*. These cars usually carry about fifty tons of coal, but some have been made which can carry as much as 120 tons of coal. The trucking of coal directly from the mines has been gaining rapidly in importance. But the railroads still carry more than nine times as much coal away from the mines as do trucks.

Coal is also shipped by barge, because many mines are located on rivers and water transportation is cheaper than shipping by rail. Millions of tons of the coal mined in Pennsylvania and West Virginia are shipped in this way on the Ohio River and its branches. Some of the coal produced in Ohio, Kentucky, Illinois, and Alabama is also shipped by river.

In eastern Ohio, fine coal mixed with water has been delivered from the mine by pumping it through a pipe line in much the same way water is pumped through a city water system.

Much of the coal mined in the Appalachian area is taken by rail to Lake Erie or to the Atlantic Coast, and from there it is shipped by boat or ship. When the rail-

Bureau of Mines

road cars reach the transfer point, they are run over huge docks which have storage bins large enough to hold whole trainloads of coal. From the bins, which are built high above the water, the coal is dumped into freighters. The coal which is sent by boat on the Great Lakes is loaded at Toledo, Sandusky, Huron, Lorain, Cleveland, Fairport Harbor, Ashtabula, and Conneaut, all in Ohio; and at Erie, Pa.; and Buffalo, N.Y. A modern lake steamer can carry 13,700 tons of coal.

From these points, the coal freighters go to various places in Canada and the United States. Most of the shipments are to Detroit; Chicago; Milwaukee; Superior, Wis.; and Duluth, Minn. Boats returning from Minnesota and Wisconsin usually bring back iron ore. Most of the coal that is shipped along the Atlantic Coast is loaded at Charleston, S.C.; Hampton Roads, Va.; Baltimore; Philadelphia; and New York City. Most of this coal goes to the New England states, which have no large coal deposits.

On Cape Breton Island, at the far eastern tip of Canada, coal beds extend from the land out under the ocean for some distance. From the mines, located along the shore, the coal is loaded directly into ocean vessels.

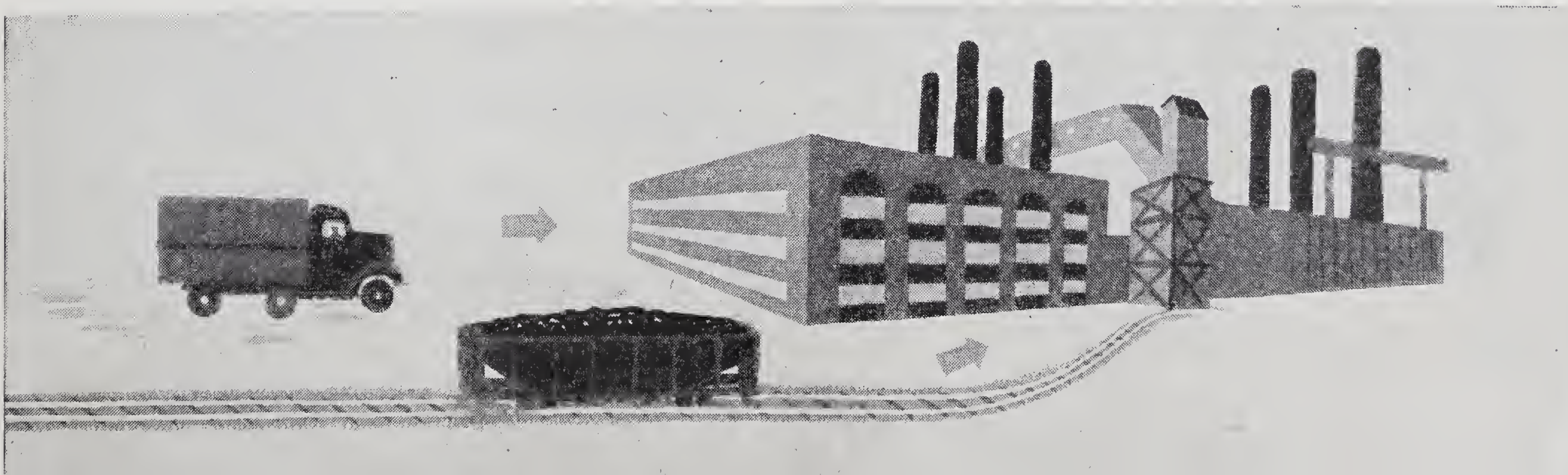
Canada is the only country which imports large quantities of coal mined in the United States. Most of the coal goes by railroad or lake freighters to the industrial section of Canada lying north of Lake Erie and Lake Ontario, or to the upper valley of the Saint Lawrence River. The coal arriving by ship is unloaded by huge cranes that scoop it out of the hold, and pile it for storage at the docks or load it on railroad cars for shipment farther inland.

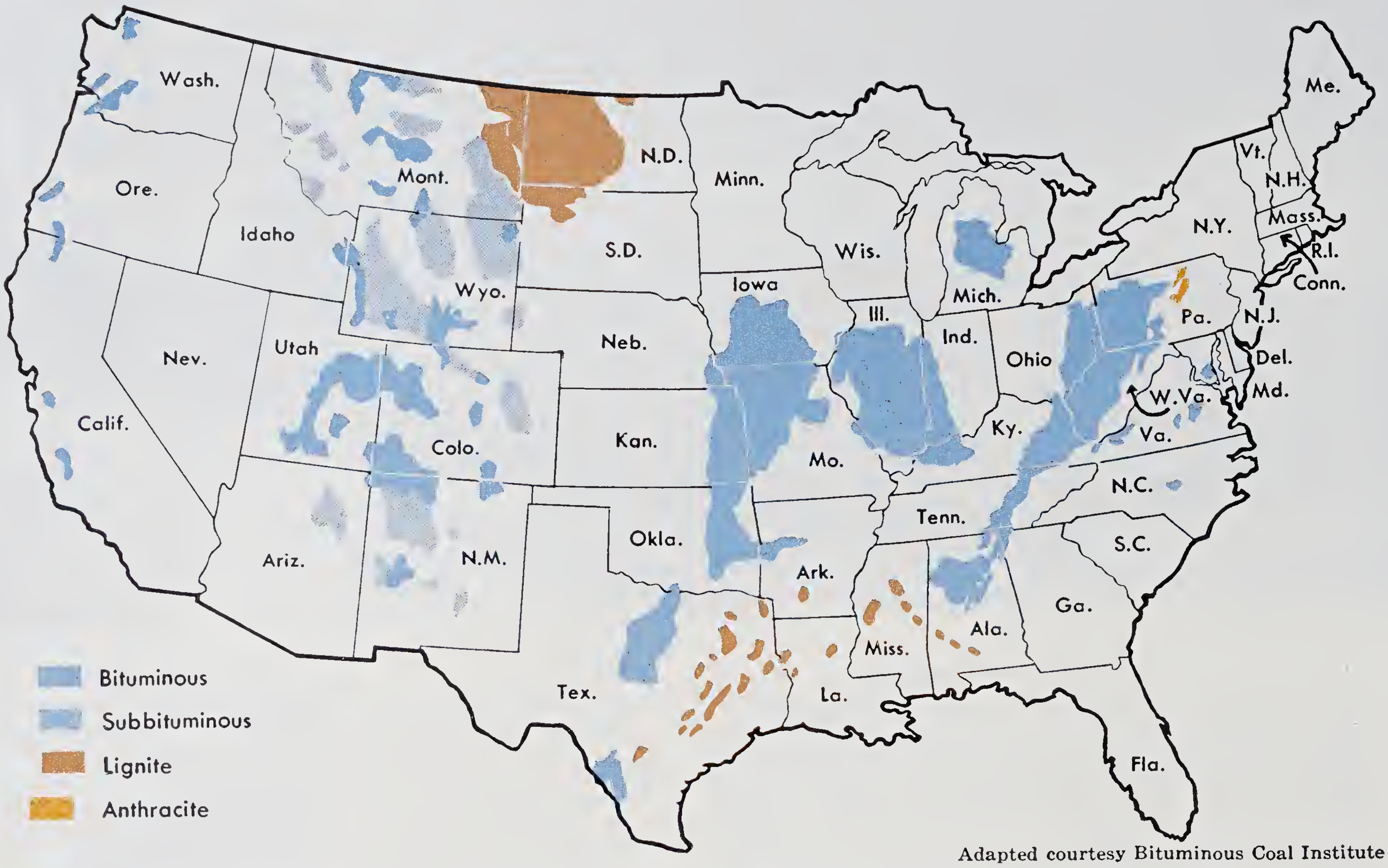
Storing. Most large consumers of coal try to keep a supply on hand which will last several months beyond their immediate requirements. Sometimes coal is stored in the open, and sometimes in bins. Anthracite and bituminous coal may be kept for long periods of time without losing their heating or power values. But subbituminous coal must be stored or piled carefully to protect it from the weather, and lignite cannot be stored without drying.

A major problem of coal distributors is having on hand the right grades and sizes of coal to meet the demands of the market. In coal yards there are usually a large number of bins, each containing a reserve supply of coal of a certain grade. Yet many retail deliveries are made directly from railroad cars. Retail dealers, as a rule, combine coal distribution with other lines of business, particularly ice, lumber, and general hauling. These dealers usually deliver coal by truck.

Where Coal Is Found

World Coal Fields. Most of the world's coal fields have already been located. Nearly half of the world's supply of coal is located in the United States, and about three fifths of all the world's coal lies in North America. The United States has over three times as much coal as Europe and two times as much as Asia. Canada, too, is well supplied with coal, having about as much as Europe and more than half as much as all Asia. Taken together, all the European countries have a little more than one ton out of seven of the world's reserves. Germany has the largest share of European coal resources. England also has large coal deposits. Asia has about one





Adapted courtesy Bituminous Coal Institute

Leading Coal Areas of the United States, Showing the Kinds of Coal Mined

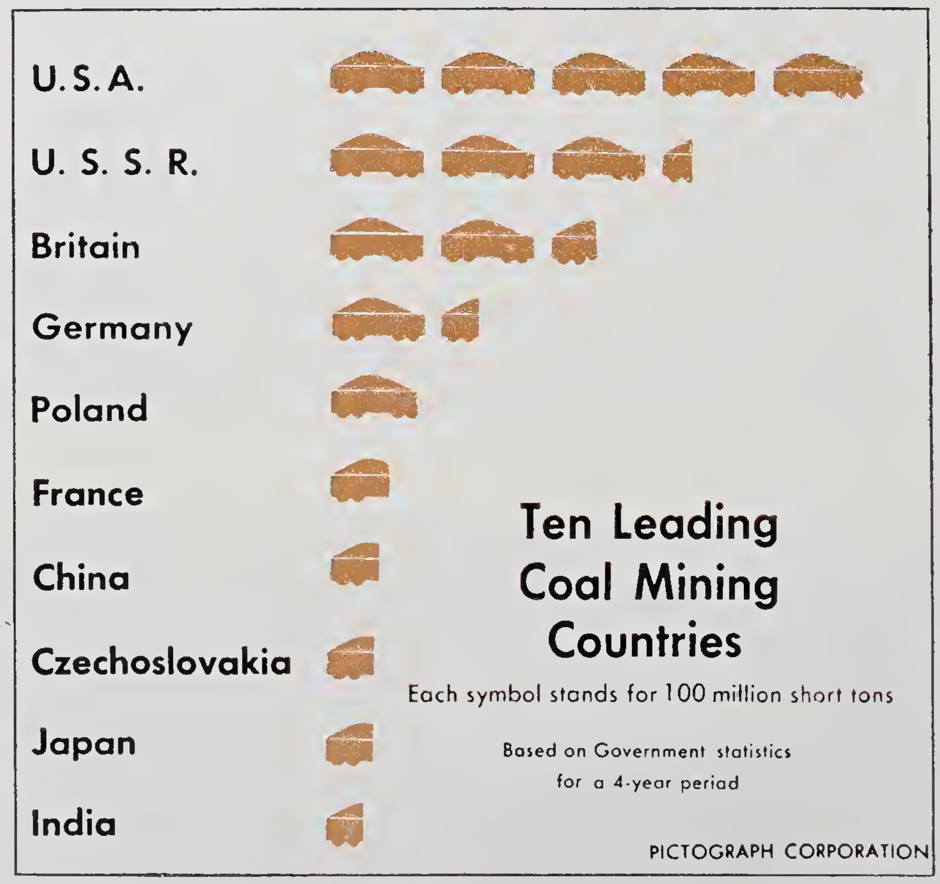
ton out of every four tons. China, Indochina, and the Soviet Union have larger deposits of hard coal than the United States, however. The Southern Hemisphere has very little coal. Africa and South America together contain only one ton out of every thirty of the world's coal resources.

United States Coal Fields. The chief coal fields of the United States are spread over several wide areas. The great Appalachian coal area extends from Alabama to Pennsylvania. A second huge coal area lies in Illinois, Indiana, and western Kentucky. Another large field crosses Iowa, Missouri, Kansas, Oklahoma, and Texas. The Northwestern Plains coal area includes parts of North and South Dakota and eastern Montana. The Rocky Mountain coal area lies in western Montana, Wyoming, Colorado, Utah, New Mexico, and Arizona. The Pacific Coast coal fields lie chiefly in Washington. At least thirty-one of the forty-eight states of the Union have significant amounts of coal. Alaska has great coal reserves, but the other possessions of the United States have none worth mentioning.

Amount of Coal Mined. The United States is the world's leading coal producer and ordinarily accounts for one fourth to one third of the total output. If the coal mined in the United States in a single year were used as paving material, it would build twelve superhighways fifty feet wide and one foot thick all the way from New York to San Francisco, a distance of 3,200 miles. In recent years, more than 540,000,000 tons have been produced annually. Of this amount, about 40,000,000 tons have been anthracite, or hard coal, and the remaining 500,000,000 tons, bituminous, or soft coal.

West Virginia and Pennsylvania mine more than half of all the bituminous coal and anthracite in the country. The other chief coal-producing states are Illinois, Kentucky, Ohio, Indiana, Virginia, Alabama, Tennessee, and Utah. All these states except Utah are east of the Mississippi River, where most of the nation's coal is used. Out of every ten tons produced, seven are used in fourteen Northeastern States. In the West, a large share of the coal is used to heat homes, but use by industry is gaining.

Other leading coal-mining countries are the Soviet



Ten Leading Coal Mining Countries

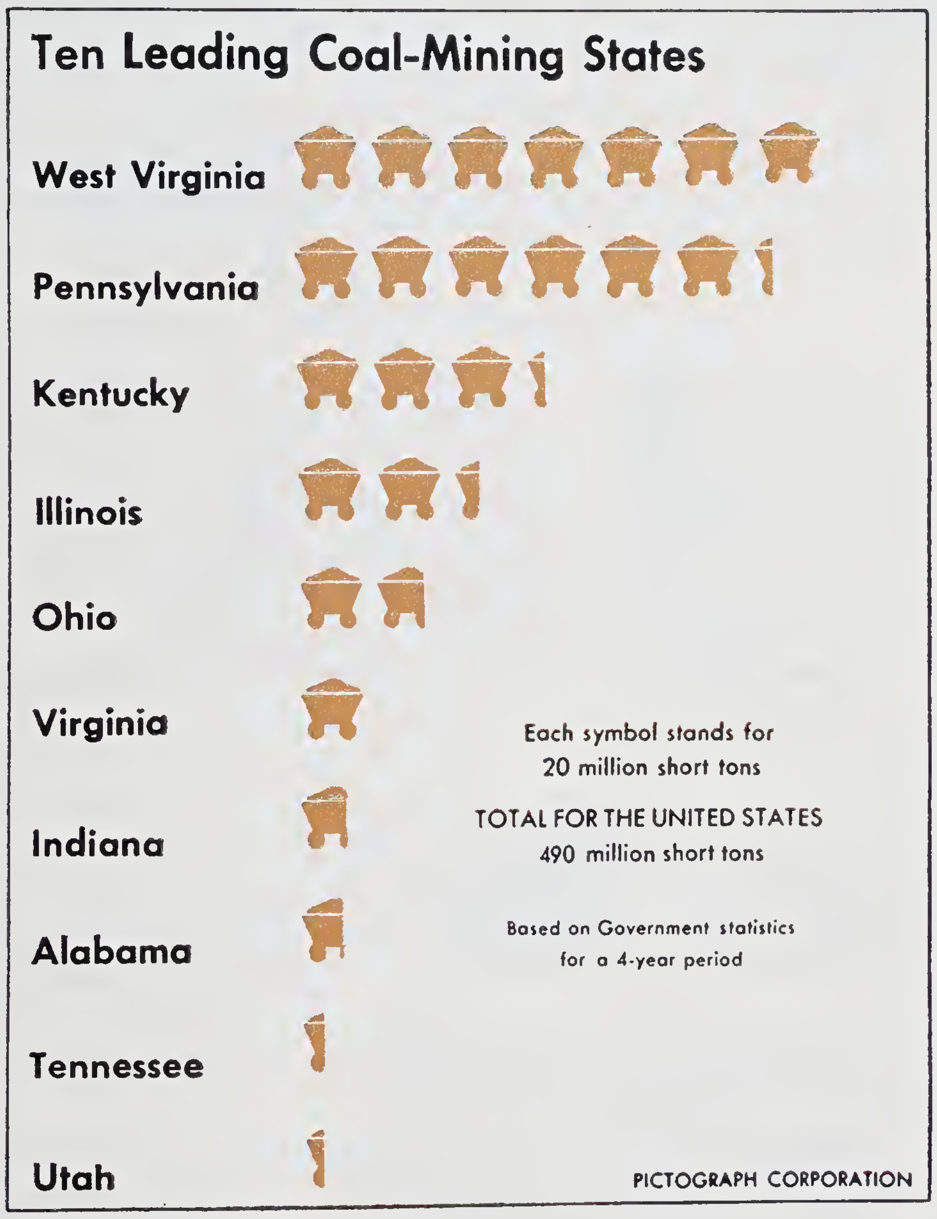
Each symbol stands for 100 million short tons

Based on Government statistics for a 4-year period

Union, Great Britain, and Germany. Together with the United States, these three countries mine three fourths of the world's output of coal. While they vary in rank, they always lead in production.

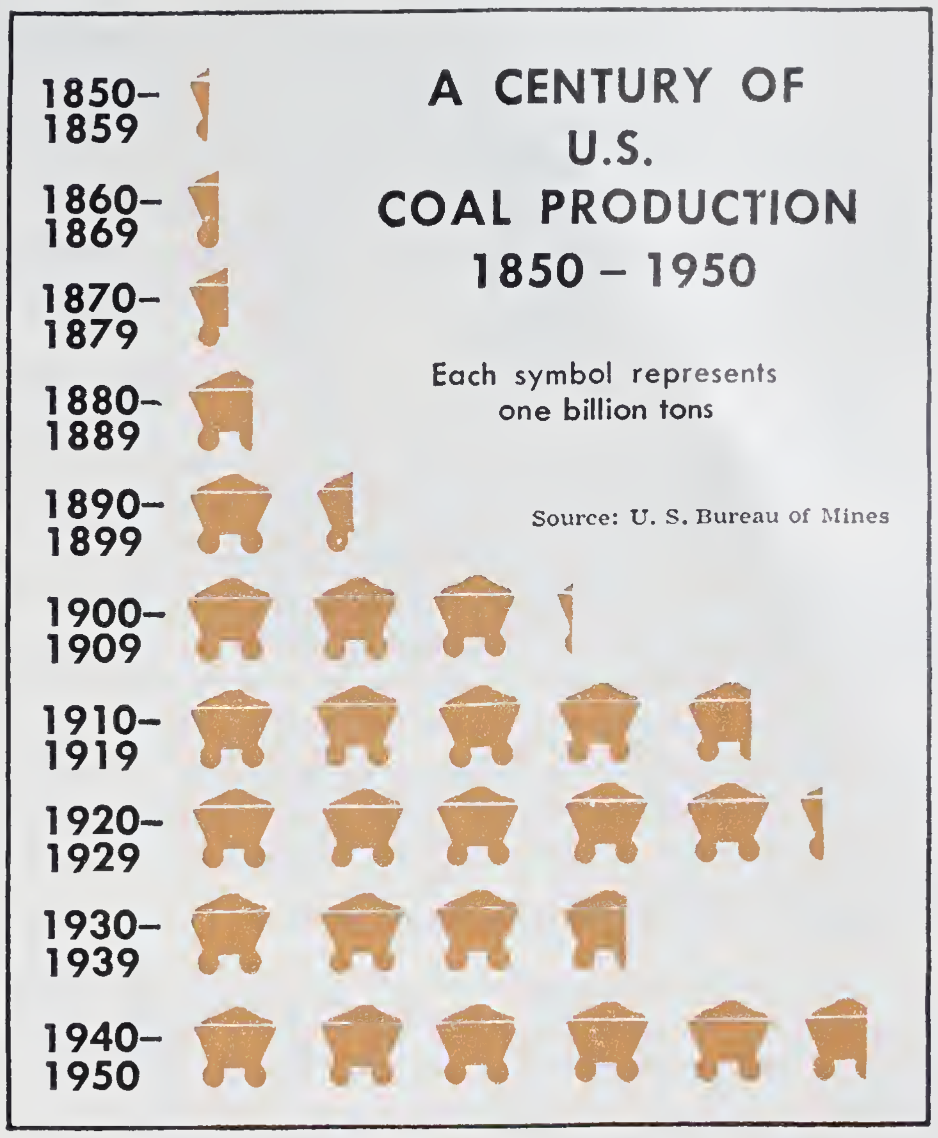
For more detailed information on the coal deposits in various states and countries, see the *Minerals* sections of the articles on the above-named states and countries.

World Coal Reserves are estimated to be about seven thousand billion tons. More than 46 per cent of this reserve is found in North America. Asia and Europe rank next in importance. United States coal reserves are estimated at three thousand billion tons. This includes beds down to three thousand feet below the surface. Some good-quality coal deposits lie even below that depth, but these are not likely to be mined for many years. Today, beds are seldom mined that are more than a few hundred feet below the surface. Coal with an ash content up to 30 per cent is included in the coal resources estimates. But, usually, coal having 15 per cent ash or less is used by consumers.



No one can tell exactly how long the coal resources of the United States will last. It is not likely, however, that they will be exhausted during the next four hundred years. They may even last more than four thousand years if the rate of use is not increased more than is necessary to replace the use of petroleum and natural gas as these valuable resources become exhausted. Some of the finest beds are gone, for the best coal always is mined first, and the poorer resources are left for the future.

Most of the unmined coal in the United States is in the Western States, far from the great eastern centers of industry.



Conservation of Coal

Coal lost or consumed can never be replaced. The conservation of this valuable resource is, therefore, a problem that concerns everyone today. It is not only a question of what to do thousands of years from now when the last ton of coal is gone. The conservation of coal is an immediate problem, since coal that is best and easiest to get is now being taken, leaving poorer grades for future generations.

Nature treated the United States generously with excellent coal resources. American mines produce four times as much coal per mine worker as those in Great Britain, and about ten times as much per worker as Belgian mines. This may be largely due to the energy and skill of American miners, and to the use of better machinery than in other countries. But these are probably not the only reasons. In the United States, the coal is taken from comparatively shallow mines. The deepest mine in this country is in the anthracite region, and it goes down about 2,200 feet, but most of the coal mines are less than 300 feet deep. In other countries, many mines go down 3,000 to 4,000 feet, and very thin beds of coal are worked. Where such conditions exist, mining is necessarily slower and more expensive.

Some of the most desirable beds in the United States already have been exhausted. Coking coals are decidedly limited. About 30 per cent of the better coal in the anthracite region of Pennsylvania has been worked out.

The geography of coal deposits is an important factor in its conservation. Six states east of the Mississippi River now produce 85 per cent of all the coal in the United States, but they have only 23 per cent of the coal resources. On the other hand, seven states west of the Mississippi River have 68 per cent of the coal reserves, but they produce only 6 per cent of the coal.

For every ton of coal mined, more than one half ton is lost. The greatest source of loss is in coal pillars left in the mines to support roofs, although recent changes in mining methods promise to reduce this loss. Other losses occur in coal preparation and handling. Much valuable coal is also left in places that are hard to reach, on the roofs and floors of mines, and under buildings and other surface structures.

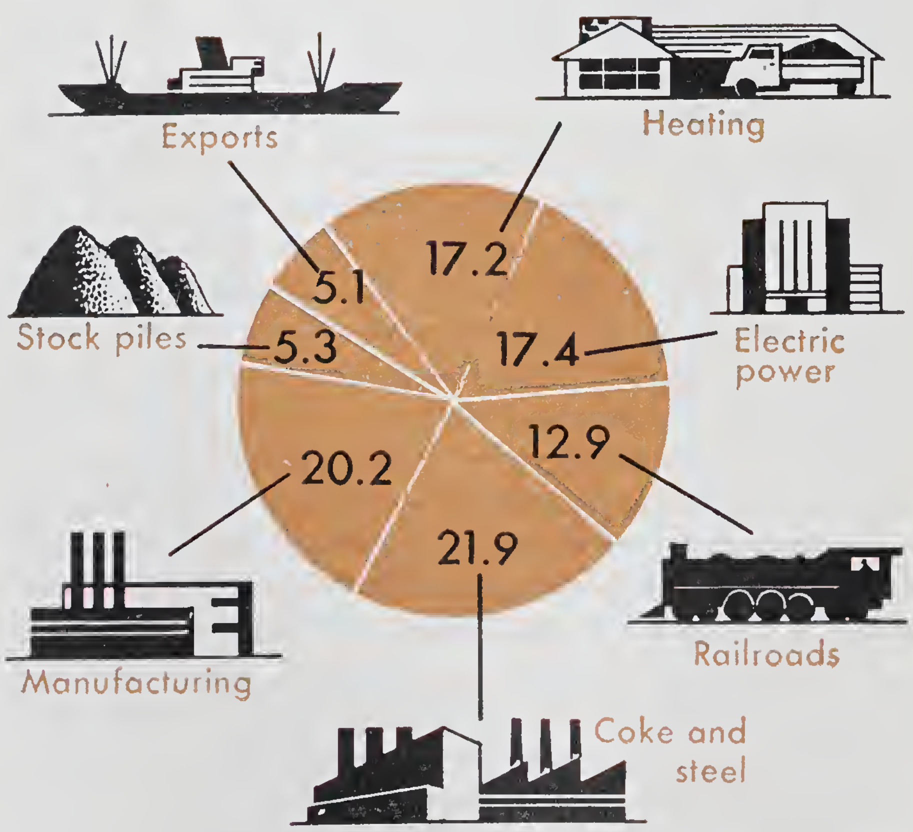
Large amounts of this precious fuel are also being wasted by consumers through careless firing methods. The introduction of automatic stokers, which use a greater part of the heat value, is helpful. Better insulation of homes and other buildings also helps to conserve coal resources. Coal smoke and soot are indications of waste. Therefore, an effort is being made to eliminate them, to conserve coal and also make cities cleaner and more healthful places in which to live. One of the major advances in coal conservation has been the shift from beehive coke ovens, which waste the by-products, to by-product coke ovens, which save them.

How Coal Is Used as Fuel

About half of the electricity in the United States is generated from coal. Coal becomes electricity by being burned under boilers full of water. The water turns into steam. The steam spins turbines and generators which make the electricity. One ounce of coal makes as much electricity as 100 tons of water falling one foot. The electric-utility industry uses more than 80,000,000 tons of bituminous coal each year.

Steel cannot be made in large quantities without coke, which is bituminous coal with the tar and gases baked out. Imagine what life would be like without steel! There would be no automobiles, airplanes, trains, ocean liners, or skyscrapers. The iron and steel industry in the United States uses about 110,000,000 tons of coal each year.

USES OF BITUMINOUS COAL



For every 10 tons of bituminous coal mined, only about one ton of anthracite is mined. Most anthracite is used for heating.

Adapted courtesy Bituminous Coal Institute, U.S. Geological Survey

Coal heats about one third of the homes in the United States and provides heat and energy for a large share of the factories. Huge amounts of coal are used each year to drive railroad locomotives and as fuel for ships, especially the ships on the Great Lakes.

Coal is necessary even for the production of atomic energy. United States atomic-energy plants use millions of tons of coal each year to make the electricity needed to run the plants.

Coal has played a leading part in the course of history and in the struggles between nations. Wars have been fought to gain or keep coal fields. This is because industrial success depends to a large extent upon the amount of coal a country controls. The coal reserves of Alsace-Lorraine and of the Ruhr and Saar basins of Western Europe have been one of the causes of many conflicts in that part of the world. Victory or defeat in war may depend upon a nation's possession or lack of coal. This is because arms and munitions cannot be produced without coal.

Thick beds of coal have determined the location of cities, because it is cheaper to ship iron ore to coal centers than it is to take coal to iron fields. Thus, coal has made great industrial centers such as Birmingham, Ala., and Pittsburgh, Pa.

Products from Coal

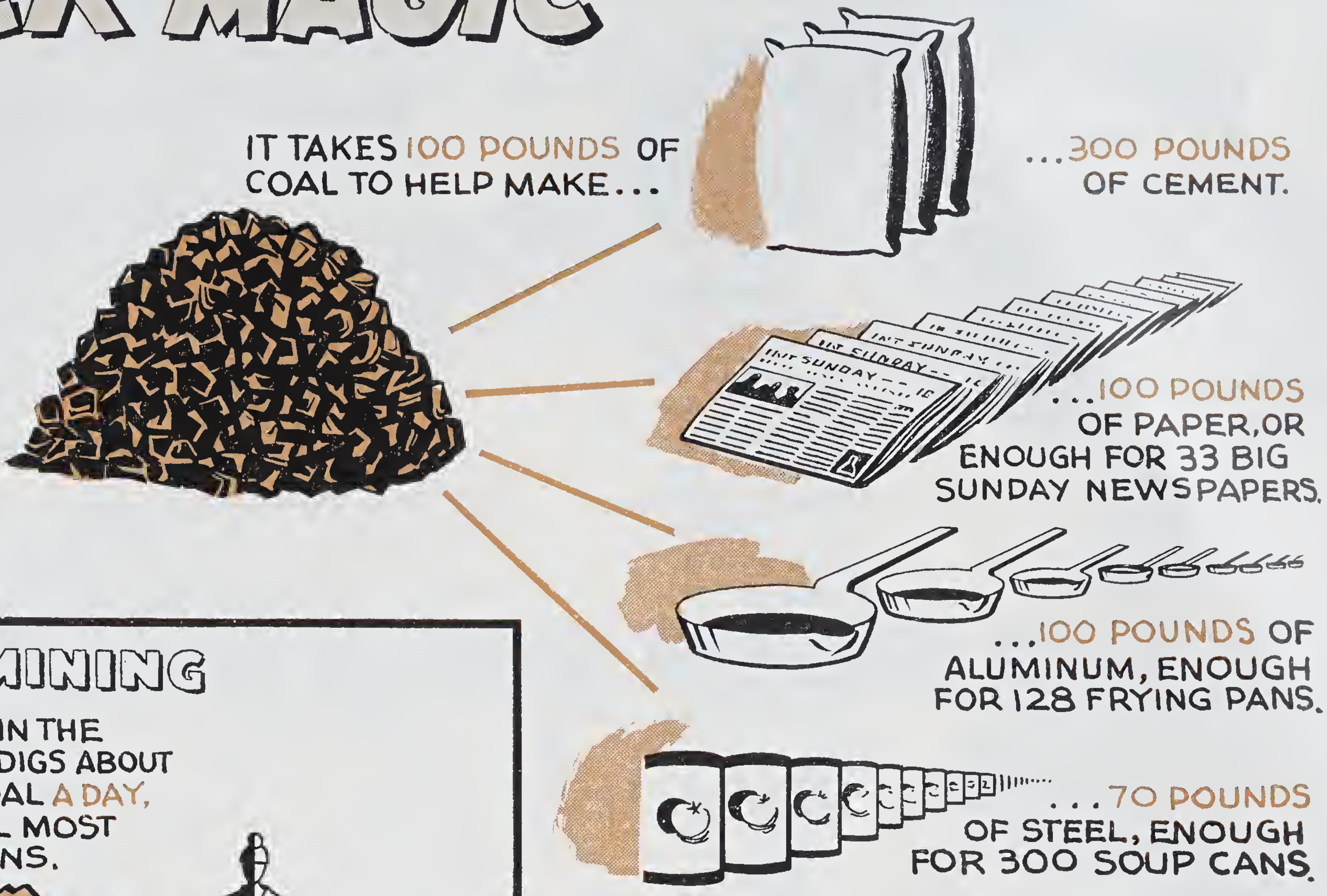
You use coal every day, although you may not recognize the coal as fingernail polish, a doll, moth balls, or the detergent with which you wash dishes. Chemicals obtained from coal are used to make these and thousands of other useful articles. Four of the main processes used to obtain valuable man-made products from coal are described below.

Carbonization consists of baking coal in an airtight oven. In this process, about two thirds of the coal is changed into either *coke* or *char*, depending on the quality of the coal baked. Coke is particularly useful in making iron and steel, and as an industrial fuel. One third of the coal baked turns into tar and gas. Coal tar is used in road surfacing and as a raw material that can be broken down into hundreds of useful chemicals. Coal gas, or coke oven gas, is used as a fuel gas and as a raw-material source of industrial chemicals. See COKE; GAS (fuel) (Manufactured Gas).

Hydrogenation is a process of treating coal with oil and hydrogen under heat and pressure, then separating the liquid mixture into useful products. Hydrogenation produces hydrocarbon gases such as ethane, propane, and butane. It produces low-priced pitch. And it turns out many valuable chemicals such as benzene, phenol, naphthalene, and aniline. These chemicals in turn are used to make everyday products such as dyes, perfumes, paints, and plastics. The hydrogenation process also can be used to produce fuel oil and gasoline. The first commercial use of hydrogenation in the United States was in 1952 at a plant built in West Virginia by the Union Carbide & Carbon Corporation. See HYDROGENATION.

Gas Synthesis, or the Fischer-Tropsch process, is a method of developing chemicals from coal by oxidation. The first step is to turn pulverized coal into a gas by exposing the coal to oxygen and superheated steam. The gas, a mixture of carbon monoxide and hydrogen, in

BLACK MAGIC



IT TAKES 100 POUNDS OF COAL TO HELP MAKE…

…300 POUNDS OF CEMENT.

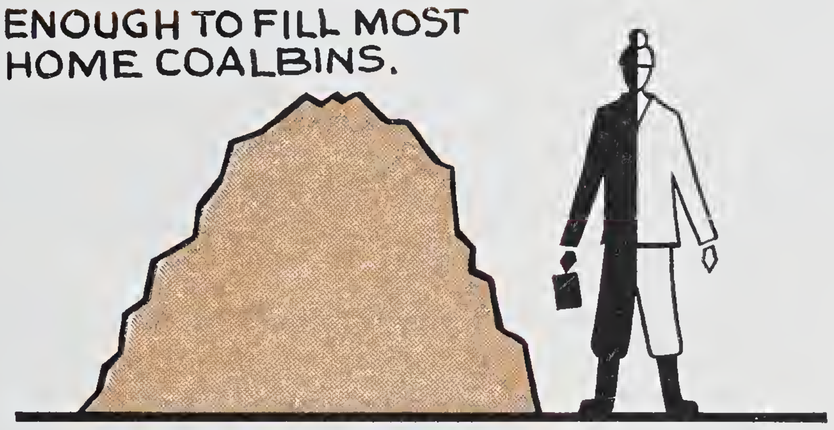
…100 POUNDS OF PAPER, OR ENOUGH FOR 33 BIG SUNDAY NEWSPAPERS.

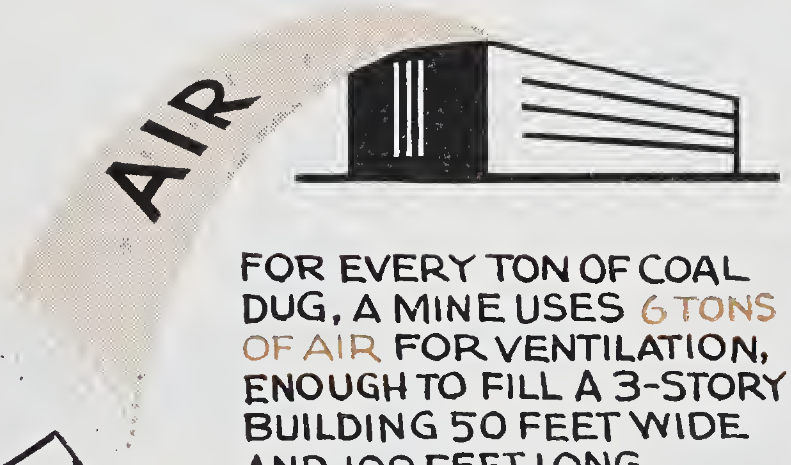
…100 POUNDS OF ALUMINUM, ENOUGH FOR 128 FRYING PANS.

…70 POUNDS OF STEEL, ENOUGH FOR 300 SOUP CANS.

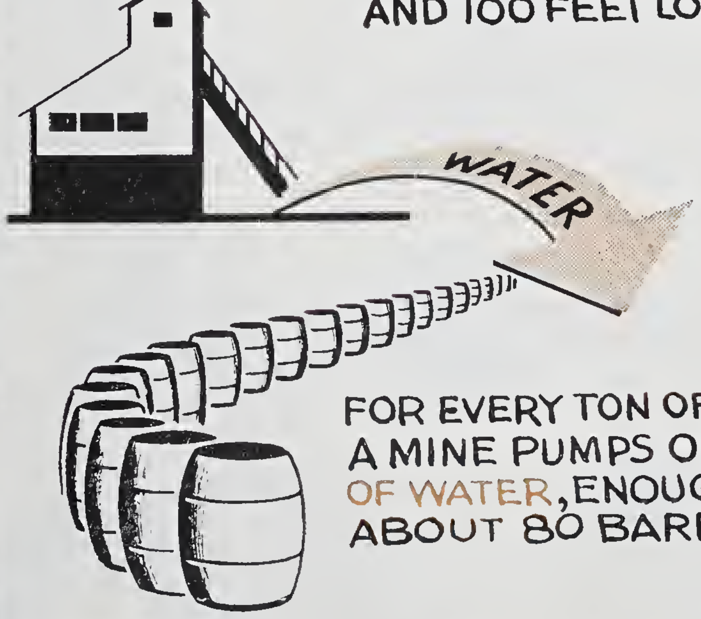
MINING

A COAL MINER IN THE UNITED STATES DIGS ABOUT 6½ TONS OF COAL A DAY, ENOUGH TO FILL MOST HOME COALBINS.





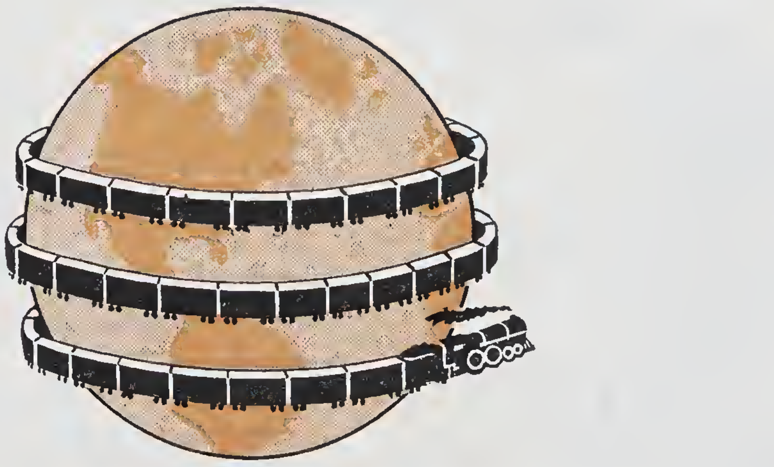
FOR EVERY TON OF COAL DUG, A MINE USES 6 TONS OF AIR FOR VENTILATION, ENOUGH TO FILL A 3-STORY BUILDING 50 FEET WIDE AND 100 FEET LONG.



FOR EVERY TON OF COAL DUG, A MINE PUMPS OUT 10 TONS OF WATER, ENOUGH TO FILL ABOUT 80 BARRELS.

TRANSPORTATION

ONE OF EVERY 5 FREIGHT CARS USED BY THE RAILROADS HAULS COAL.



THE AMOUNT OF COAL MINED IN A YEAR IN THE UNITED STATES WOULD FILL A TRAIN LONG ENOUGH TO REACH AROUND THE EARTH 3 TIMES.

PREPARED WITH CO-OPERATION OF BITUMINOUS COAL INSTITUTE: LEHIGH NAVIGATION COAL CO.

Uses of Coal Products

Listed below are many of the products of coal (in black type) and some of their uses (in lighter type).

Coal Tar

- **Tar acids**
  - **Carbolic acid**
    - Aspirin
  - **Cresols**
    - Lysol
    - Photo developer
    - Plastics
- **Methyl naphthalene**
  - DDT insecticide
  - Fungicides
- **Naphthalene**
  - Baby dolls
  - Explosives
  - Moth balls
  - Upholstery
- **Phenols**
  - Detergents
  - Drugs
  - Dyes
  - Food preservatives
  - Oil of wintergreen
  - Perfumes
  - Rubber chemicals
  - Weed killer
- **Pyridine**
  - Clothes waterproofing
  - Sulfa drugs
  - Synthetic vitamins
- **Heavy oil**
  - Embalming fluid
  - Laxatives
  - Wood preservatives
- **Pitch**
  - Electrodes
  - Paving
  - Roofing
  - Storage batteries
  - Waterproofing
- **Tar bases**
  - Antiseptics
  - Disinfectants
  - Paint thinner

Light Oils

- **Adipic Acid**
  - Nylon
- **Benzene**
  - Aniline dyes
  - Food preservative
  - Indelible pencils
  - Motor fuel
  - Plastics
  - Synthetic rubber
  - Tanning fluids
- **Carbon disulfide**
  - Rubber solvent
- **Solvent Naphtha**
  - Electrical insulation
  - Linoleum
  - Varnish
- **Toluene**
  - Antiseptics
  - Fingernail polish
  - Printing ink
  - Saccharin
  - TNT explosive
- **Xylene**
  - Colored ink
  - Cosmetics
  - Synthetic fibers

Chemicals

- **Ammonia**
  - Household use
  - Paper manufacture
  - Refrigeration
  - Smelling salts
- **Ammonium chloride**
  - Dry batteries
  - Galvanizing
- **Nitric acid**
  - Explosives
  - Fertilizers
- **Nitrous oxide**
  - Laughing gas anesthetic
- **Urea**
  - Adhesives
  - Plastics

Coal Gas

- **Cyanogen**
  - Artificial silk
  - Cotton finishing
  - Dyes
  - Poison gas
- **Fuel gas**
- **Illuminating gas**
- **Sulfur**
  - Fungicides
  - Insecticides
  - Sulfuric acid

Coke and Coke Products

- **Acetic acid**
  - Paint
- **Acetylene**
  - Welding
- **Baking powder**
- **Battery carbon**
- **Carbide**
- **Carbon dioxide**
  - Fire extinguishers
  - Soda water
- **Carborundum**
- **Carbureted water gas**
- **Electrodes**
- **Fuel**
  - In homes
  - In industry
- **Graphite**
  - Lead pencils
- **Lamp black**
- **Metallurgical coke**
  - Copper smelting
  - Iron smelting
  - Lead smelting
- **Polyvinyl plastics**
  - Phonograph records
- **Washing soda**

turn is passed over various solid catalysts to change it into useful products. Cobalt catalysts have been used to change the gas into Diesel fuel. Iron catalysts can change it into gasoline.

Gasification. Fuel gas is obtained from coal by two commercial methods which are described in the article GAS (fuel) (Coke Oven Gas; Carbureted Water Gas). Experiments have been conducted in both the United States and other countries with a process of burning the coal in the mine to produce gas, then piping the gas to the surface. The gas in turn can be used as a source of heat to make electric power, or can be broken down into liquid fuels such as gasoline.

The Mining Industry

Mine Ownership. Hundreds of concerns share in the ownership of mines. Some coal mines are owned by steel companies, railroads, or other large industries which use a great deal of coal. These mines are called *captive mines.* They account for about 20 per cent of the total production of coal.

Employment. The use of cutting and loading machines has made it possible for a smaller number of miners to produce a greater amount of coal. For example, in 1923 about 640,000 miners were employed in bituminous-coal mines of the United States. They produced 569,000,000 tons of coal. A quarter of a century later, about 400,000 bituminous miners produced 631,000,000 tons of coal. Bituminous-coal mining employs over eight times as many men as does the anthracite industry.

The United States coal miner produces more coal per day than does the average miner of any other country in the world. Bituminous miners in the United States mine an average of 7.35 tons per man every working day, compared with 3.0 tons in Canada, 1.3 tons in Poland, 1.2 tons in Great Britain, and 1.0 tons in Germany.

In addition to the men who mine the coal, hundreds of thousands of persons are engaged outside the mines in selling coal, transporting it, and handling it in coal-using industries. In all, about a million persons in the United States work for or gain their living from the coal industry.

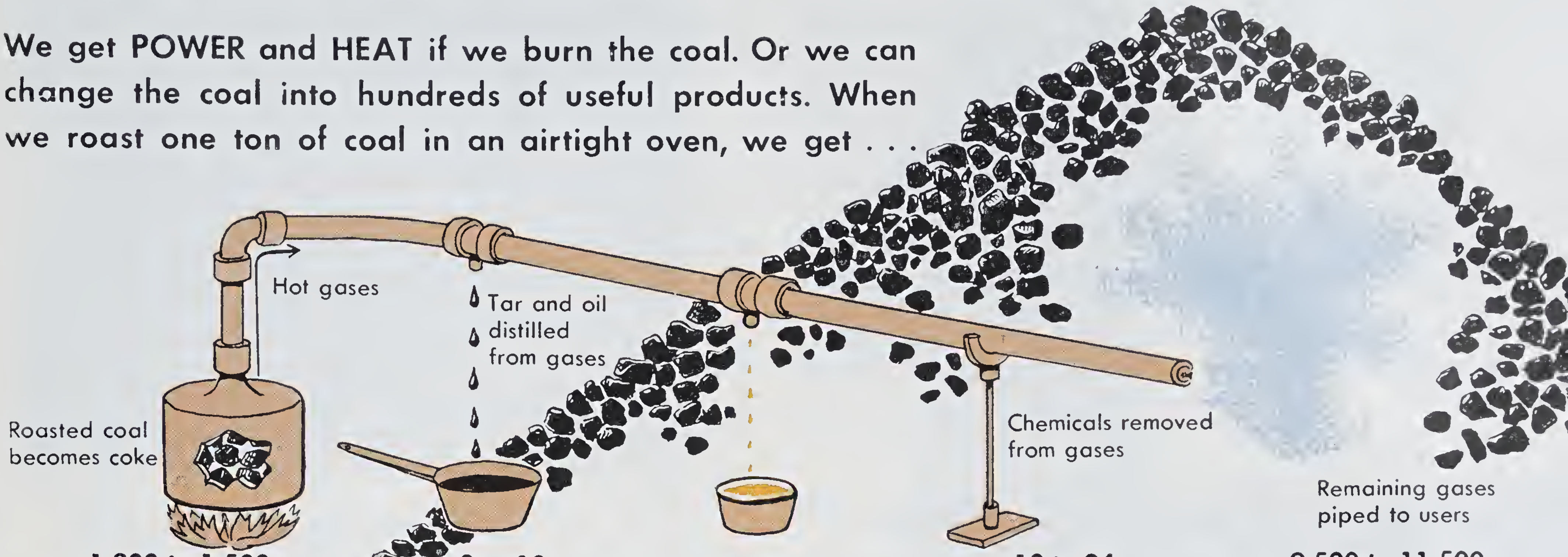
Working Conditions. Before 1898, the length of the work week in the bituminous-coal mines of the United States was sixty hours. It was reduced to fifty-two hours during the period from 1898 through 1916, to fifty in 1917, to forty-eight between 1917 and 1932, and to forty hours in 1933. Since 1934, the thirty-five-hour weekly schedule — seven hours per day and five days per week—has been in effect.

Weekly work schedules in the anthracite industry remained at sixty hours until April 1, 1903, when they were reduced to fifty-four. A reduction from fifty-four hours per week to forty-eight took place on April 1, 1916, and from forty-eight hours to thirty-five on May 1, 1937.

During World War II, most miners worked long hours of overtime, but in normal years the actual time worked by miners is less than thirty-five hours a week. Miners in the United States usually work about 210 to 250 seven-hour days a year.

WHAT WE GET FROM A TON OF COAL

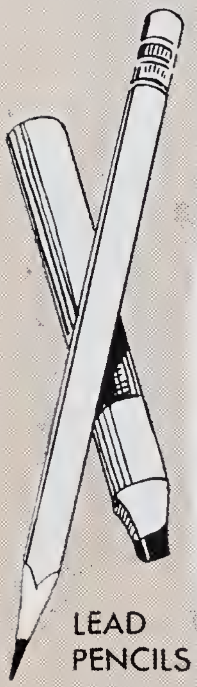
We get POWER and HEAT if we burn the coal. Or we can change the coal into hundreds of useful products. When we roast one ton of coal in an airtight oven, we get . . .


Hot gases
Tar and oil distilled from gases
Roasted coal becomes coke
Chemicals removed from gases
Remaining gases piped to users

. . . 1,300 to 1,500 pounds of

COKE

BAKING POWDER

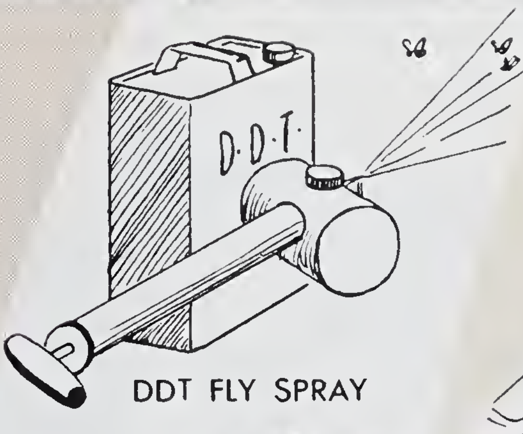

LEAD PENCILS

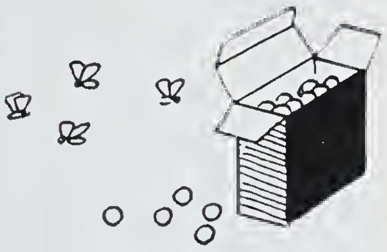
PAINT

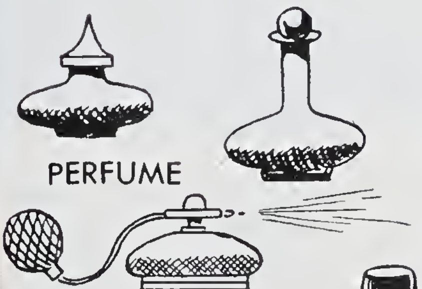
PHONOGRAPH RECORDS

. . . 8 to 10 gallons of

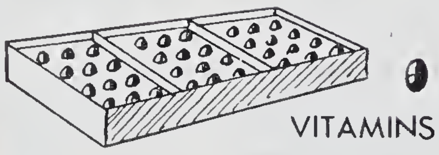
COAL TAR

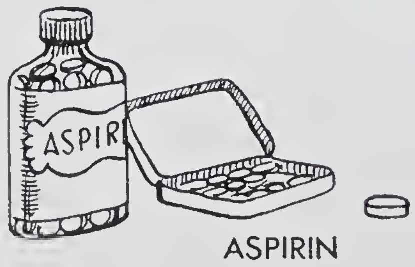

DDT FLY SPRAY


MOTH BALLS


PERFUME

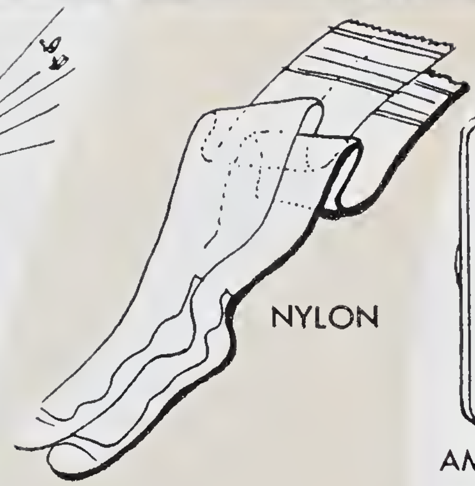
SULFA DRUGS

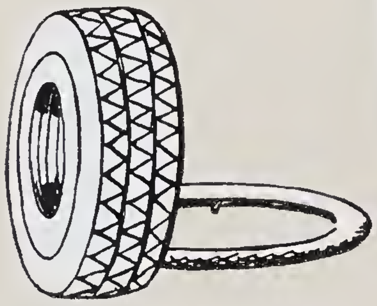

VITAMINS

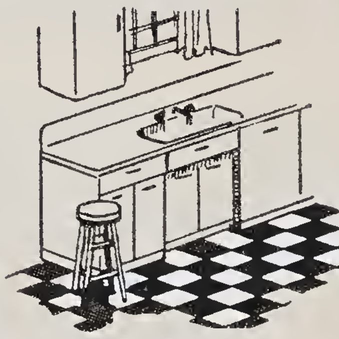

ASPIRIN

. . . 3½ gallons of

LIGHT OIL


NYLON

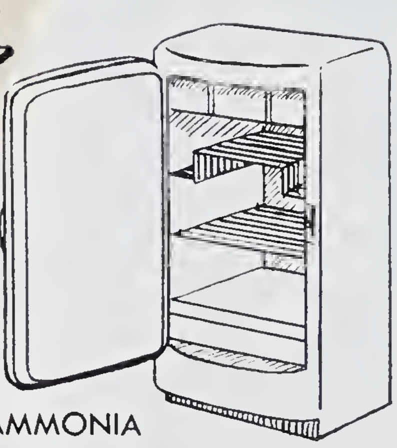

SYNTHETIC RUBBER

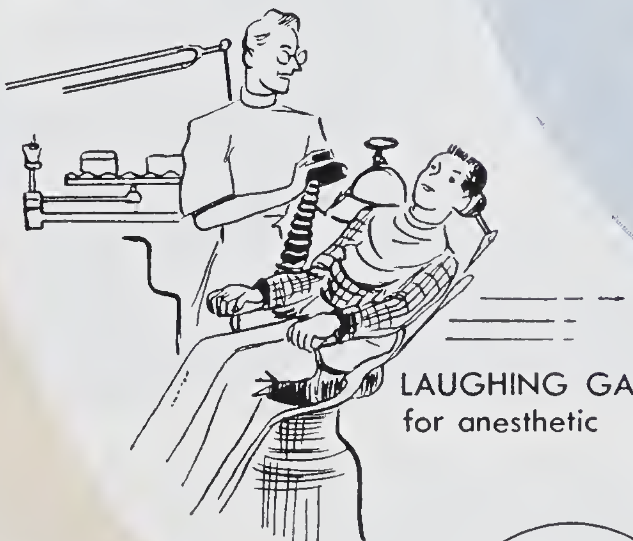

LINOLEUM

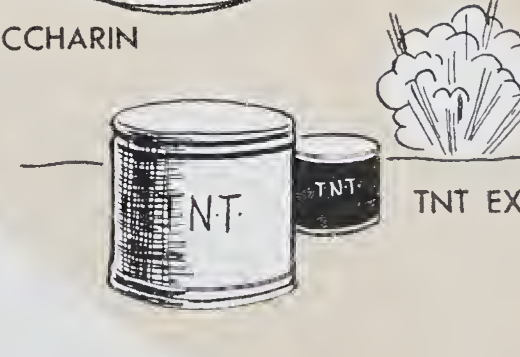
SACCHARIN

. . . 18 to 24 pounds of

CHEMICALS

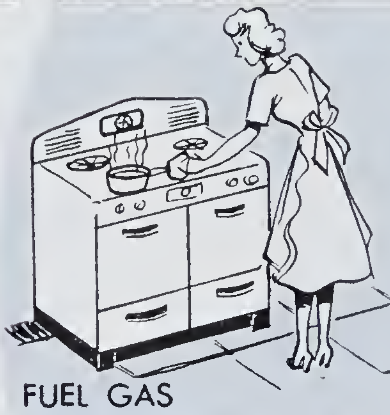

AMMONIA for refrigeration


LAUGHING GAS for anesthetic


TNT EXPLOSIVE

. . . 9,500 to 11,500 cubic feet of

COAL GAS


FUEL GAS for cooking and heating

CYANIDE a poison

PLASTIC DISHES

COSMETICS

Prepared with co-operation of U.S. Bureau of Mines

In early days, coal-mining companies built many *company towns* to provide housing for their miners, and ran *company stores* to supply the miners' needs. This was considered necessary because mines were often located in areas far from cities and towns. There were several disadvantages in the company-town system. The miners sometimes felt that they were not free to live and to buy their goods where they pleased. As retail merchants and landlords, the mining companies had a heavy responsibility to the miners. The introduction of good roads, the automobile, and higher pay made it possible for many miners to live at a distance from the mines. This brought about a decline in company towns. Today, only about one fifth of the coal miners in the United States live in company towns.

Unions. Most of the coal miners belong to the United Mine Workers of America. Under the leadership of John L. Lewis, this union has become one of the strongest in the United States.

The union negotiates contract agreements with the mine operators. These agreements deal mainly with wage rates, hours of work, working conditions, and the royalties paid by the operators into the miners' welfare and retirement fund. This fund provides pensions for retired miners, medical care for miners and their families, and death benefits for miners' families.

Importance to Other Industries. All industries are likely to be seriously affected if anything interrupts the steady flow of coal from the mines. For example, if the great steel furnaces grow cold for lack of coal, a shortage of steel may cause shutdowns in automobile plants, building construction, shipyards, and hundreds of other manufacturing industries. All other industries may be greatly hampered, not only by a shortage of coal for their own use, but also by a shortage of automobiles, new buildings, and ships. Shutdowns spreading to these other industries may throw hundreds of thousands of persons out of work, with the result that they suffer hardships and cannot buy as much of the products of industry as they usually would. At the same time, coal-heated homes may be left without fuel. Without coal to provide energy to generate electricity, entire cities may be cast into darkness and various other essential community services may be cut off. Workers on the upper floors of skyscrapers may be unable to reach their offices because there is no power for running the elevators. Radio and television stations may go off the air for lack of power.

Thus the normal operation of the coal industry is of great importance to the entire country. This is especially true in wartime. Government regulation of the coal industry in the United States was introduced under wartime conditions in 1917, during World War I, but was lifted after peace was declared.

Regulation was revived in 1933. The Federal Government established minimum prices for coal and aided in the negotiation of wage-hour agreements. This type of regulation was discontinued in 1943 when wartime regulations setting maximum prices were in effect. Since 1946 little regulation has existed except for a time after the start of the Korean war. The Government continues to play an active part in the settlement of labor disputes, and at times of national emergency has taken over operation of the coal mines when labor-management disputes interfered with production.

Mine Safety Measures

Protection Against Gases. Precautions against gas must be taken in many mines. There are many gases which displace the oxygen in the air, and make it unsafe to breathe. One of these dangerous gases is carbon dioxide. This gas often is found with deeply buried deposits of coal. Air which contains large proportions of carbon dioxide is called *chokedamp* or *blackdamp*. Chokedamp becomes a hazard when a section of the mine is cut off from a proper supply of fresh air, and oxygen from the air is absorbed by the coal or the mine timber supports. Constant ventilation of all parts of the mine prevents chokedamp.

An instrument known as the flame safety lamp is used to detect chokedamp. When chokedamp is present, the lack of oxygen makes the flame of the lamp burn lower.

Another gas found in mines is carbon monoxide. It is sometimes called *afterdamp*, because it occurs only *after* a mine fire, an explosion, or the partial burning of explosives used in breaking down coal. Carbon monoxide is caused by the incomplete burning of the coal or coal dust. A carbon-monoxide detector, carried by a man wearing a gas mask, is used to test for the presence of this dangerous gas.

Probably the most common of the dangerous gases found in mines is methane. Explosions may result when only 5 to 15 per cent of methane is found in the air. The mixture of methane with air is called *firedamp*. Methane is formed by the same chemical changes which produced coal from organic matter. For this reason it is more often found in coal mines than in any other type of mine.

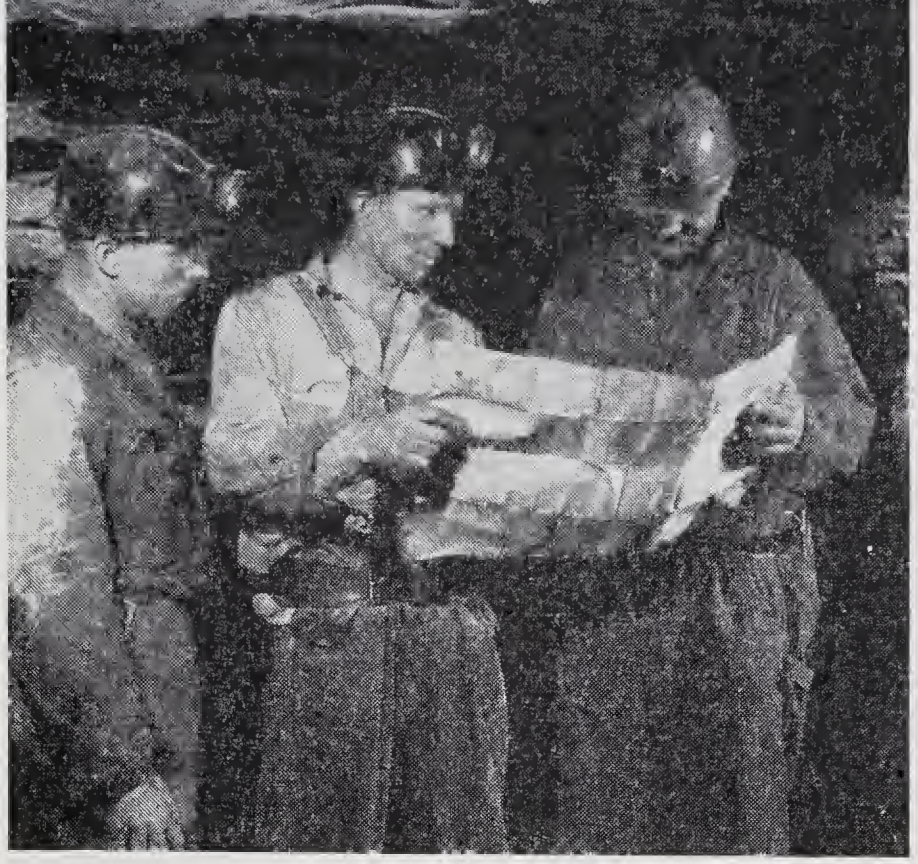
Firedamp is easily detected by a flame safety lamp, by an electrical methane-detecting device, or by on-the-ground chemical analysis of mine air samples. Methane can be kept out of coal mines by means of huge ventilating fans and ventilating doors to distribute fresh air to all mine openings. In many mines, the weight of the air which is sent through the mine passages during a day is much greater than the weight of the coal taken from the mine during that time.

For many years canary birds were used to detect gas in mines. If gas was present, the birds became sluggish and fell from their perches. Nowadays, various accurate mechanical or electrical detecting devices are used instead.

Protection Against Coal-Dust Explosions. Gas explosions in mines are usually confined to one part of the mine, and are not themselves the cause of widespread injury or loss of life. But gas may start much-feared coal-dust explosions, for coal dust is highly explosive when exposed to a flame.

The breaking of the coal for loading into mine cars or onto conveyers results in the formation of many fine particles of coal dust. If gas present with coal explodes, the tiny particles of coal dust are forced into the air and set afire. The coal dust can be made harmless by a simple process. Limestone dust is spread over all surfaces, effectively blanketing the coal dust. As another means of eliminating coal dust, water is used on the working

MINING IN SAFETY

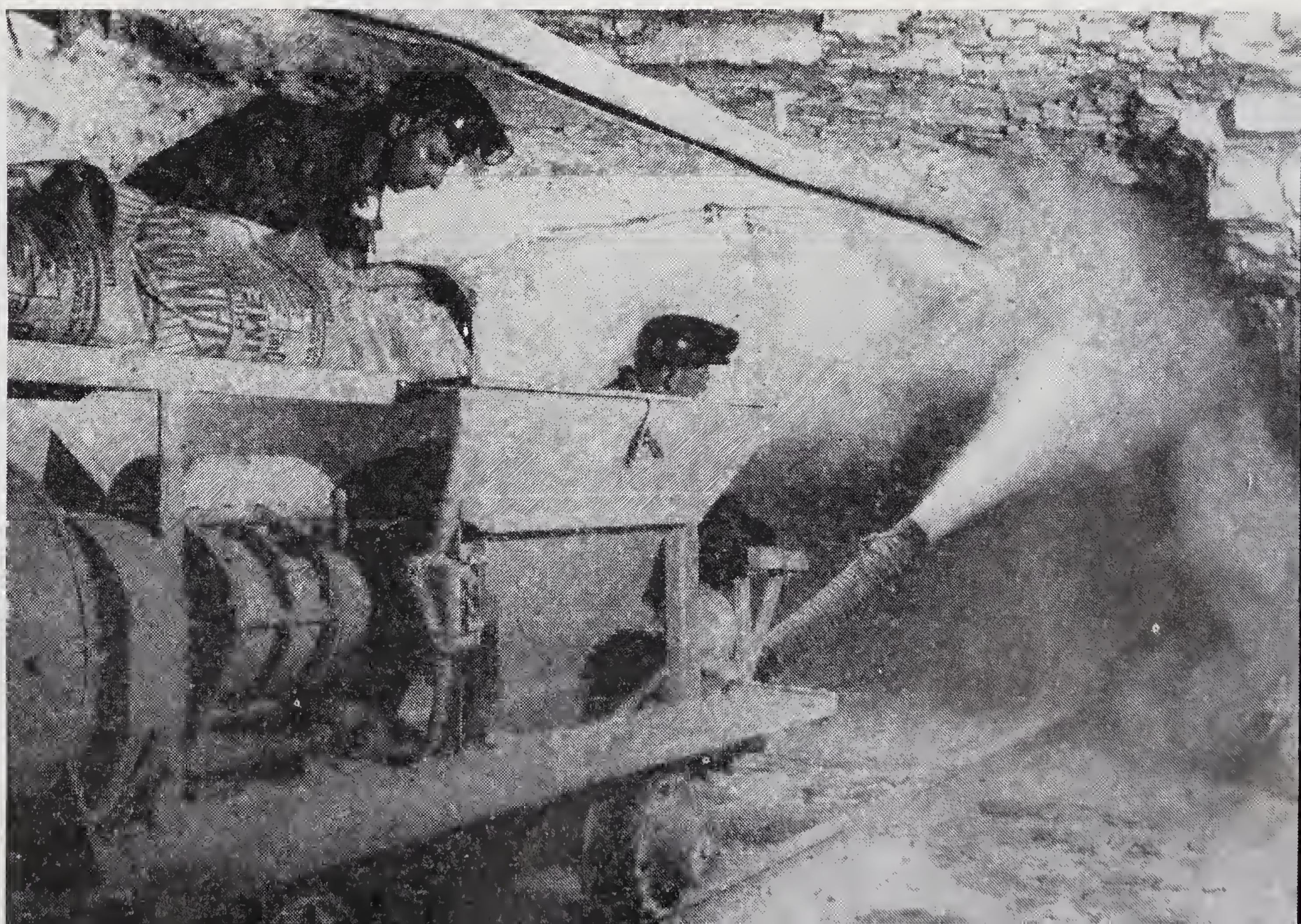


Safety Engineers talk over each mining operation with foremen and supervisors. A supervisor for each 10 to 12 miners helps insure safety.

Mine Inspector checks amount of air being blown through mine to see if men are getting enough air to breathe.

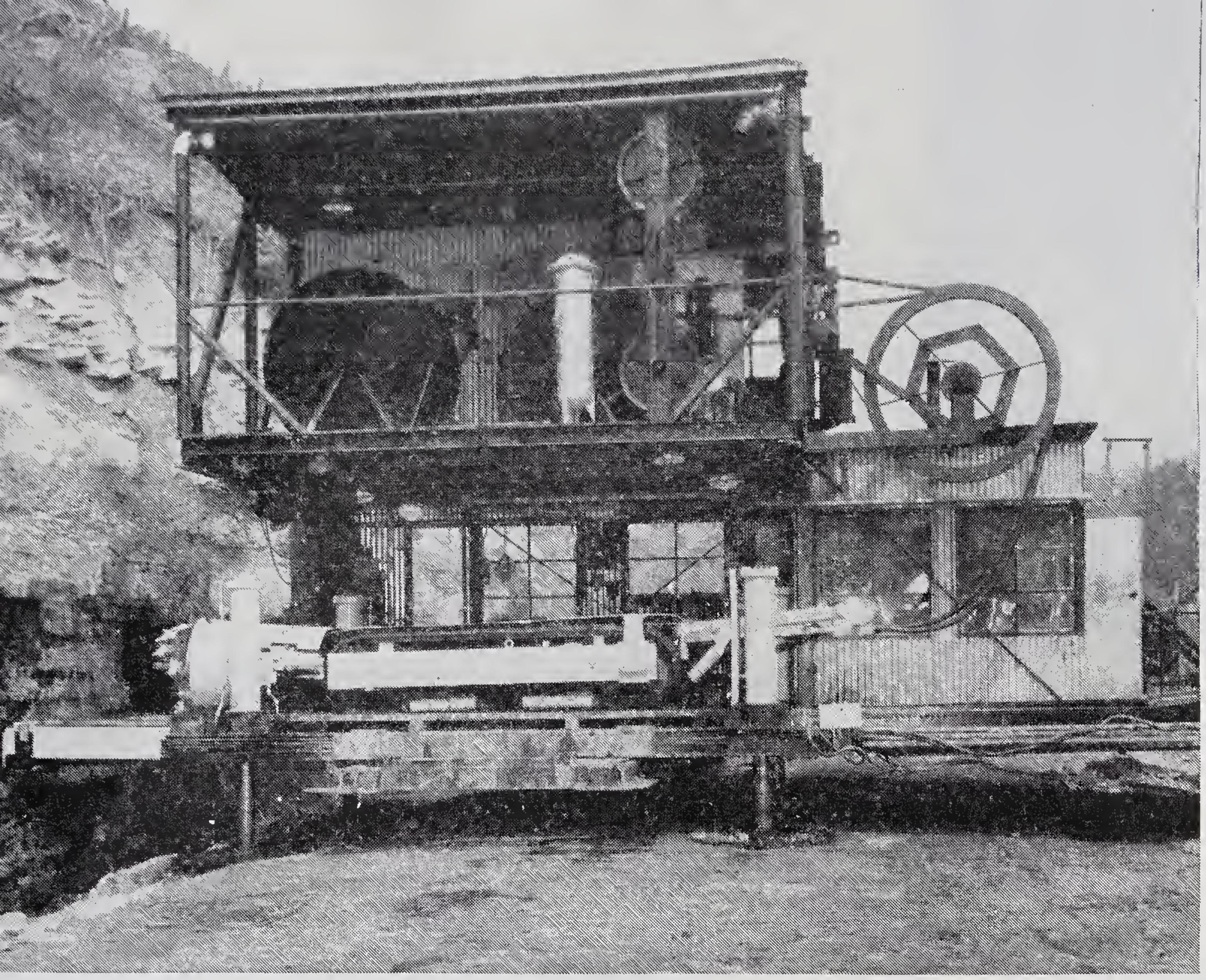
Safety Fire Boss uses lamp to test for chokedamp. If lamp flame grows dim, it means the gas is present in the air.

Mine Safety Team practices carrying miner on stretcher. A few minutes more or less in a mine disaster may mean many lives saved or lost.



Rockdusting, or coating the tunnels of a coal mine with finely powdered limestone, prevents the spread of highly explosive coal dust.

Western Kentucky Coal Co.;
Bituminous Coal Institute;
Pittsburgh Consolidation Coal Co.



Double-Deck Robot Miner chews its way into coal seams, cutting a path 10 feet wide and 3 feet high. Electronic "eyes" mounted on its cutting teeth send signals, somewhat like radar, back to the operator in the control cab. Watching these electronic signals, the operator guides the robot to follow and dig out the coal seam far into the hill.

Carbide and Carbon Chemicals Co.

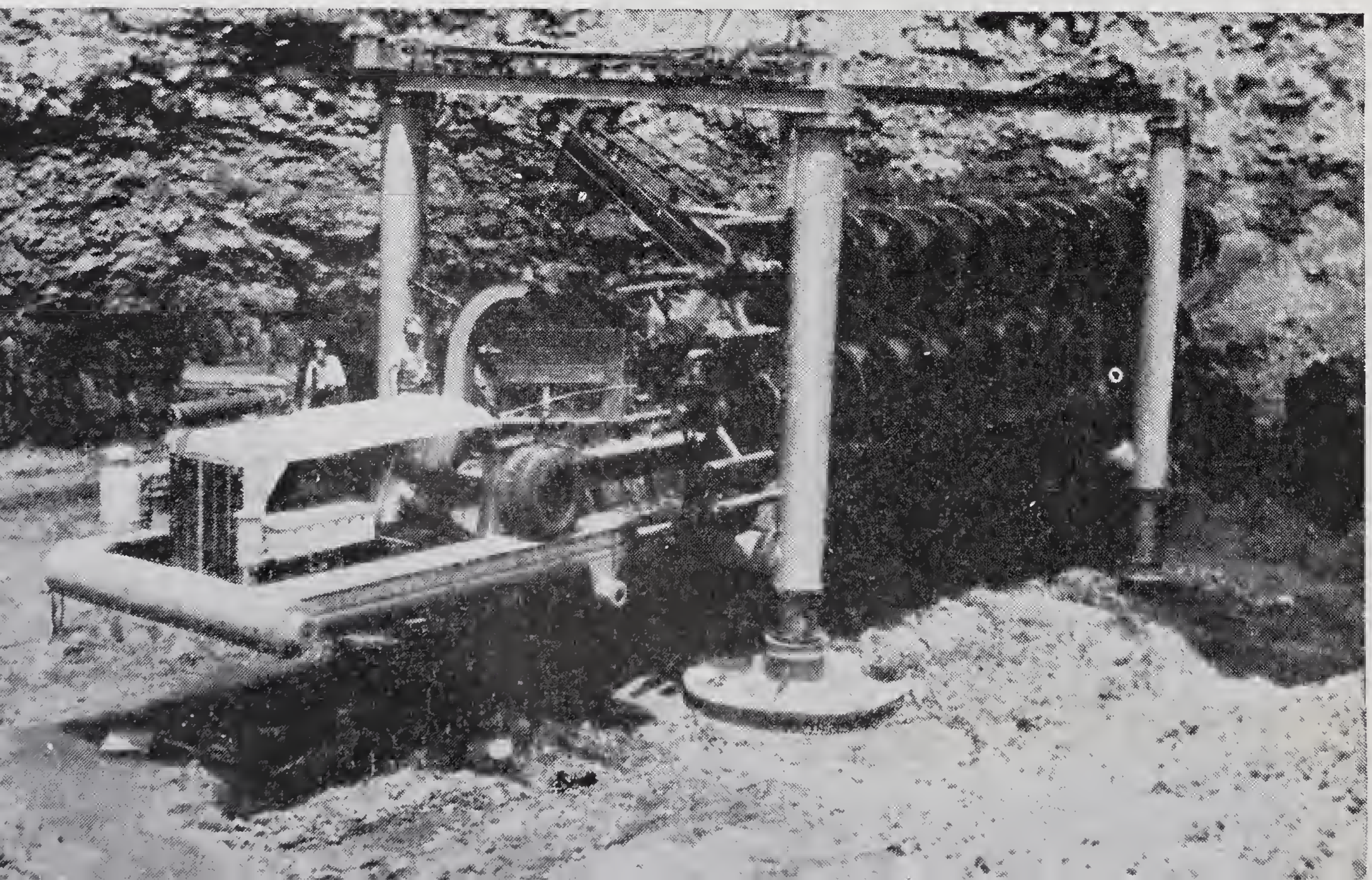
heads of the saws and shoveling parts of mining machines.

Draining the Mine. Some mines are as dry as dust. But others, especially those located far below surface or under subterranean streams, are flooded with large quantities of water, which must be pumped out constantly. In such mines, drainage is a problem, and flood waters may endanger the lives of the miners. In the anthracite region of Pennsylvania, as much as thirty-three tons of water may be pumped out for every ton of coal mined. In some places the water which is pumped from the mines pollutes near-by streams and local water supplies. This water contains sulfur and other impurities, and often destroys the fish in the streams and makes the water unfit for human use. The Federal Government has spent large sums of money to seal abandoned mines which threatened the water supply in certain areas.

Protection Against Other Hazards. The greatest number of injuries in coal mines are caused by material falling from the mine roof, and by accidents in hauling the coal away from the mine face. Steel and reinforced-concrete pillars are sometimes used in main haulageways, or steel plates may be bolted to the roof, doing away with timbers to support the roof.

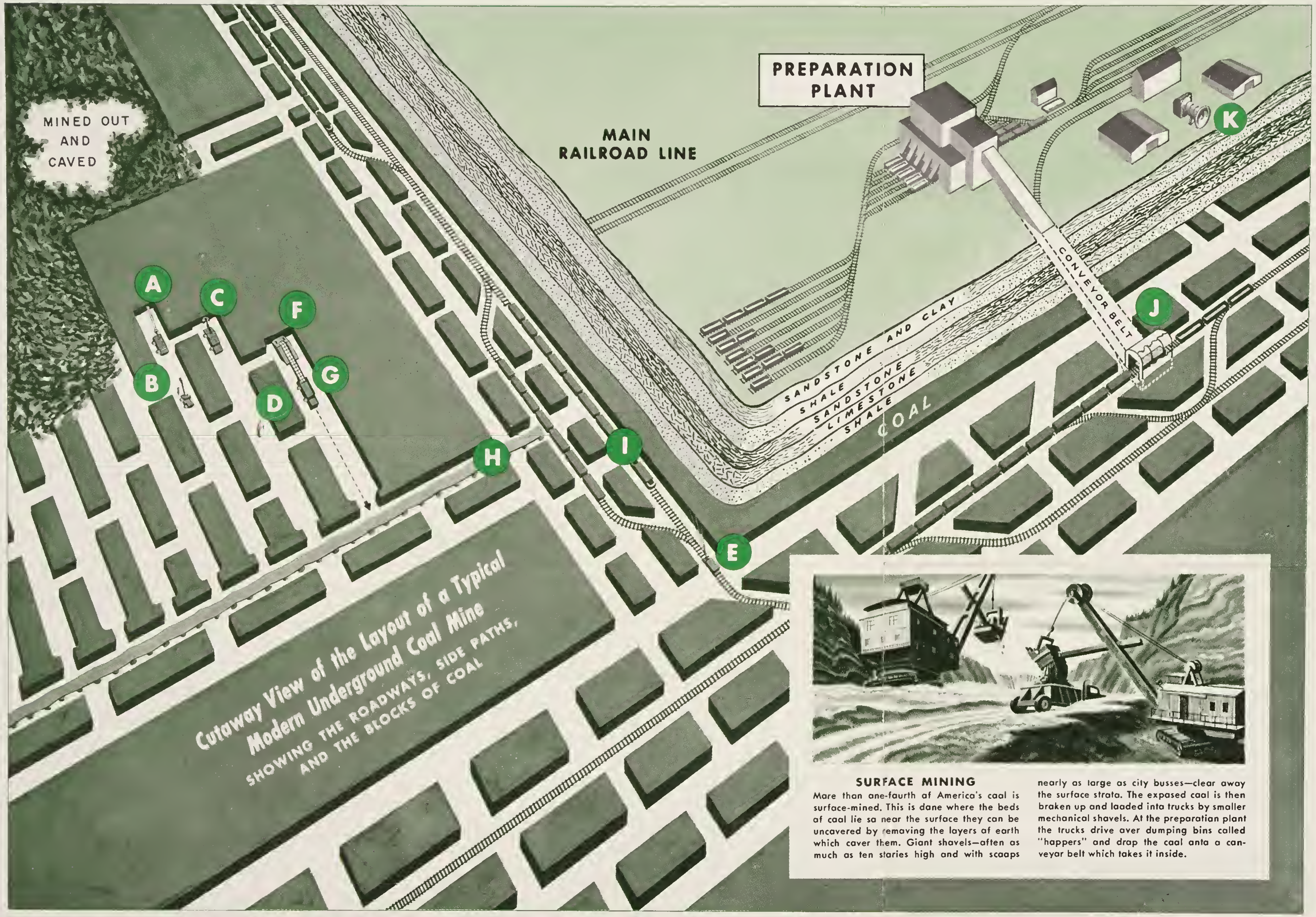
Some of our most valuable deposits of high-quality coal are found in layers only thirty to forty inches thick. It is sometimes necessary to remove rock from above or below the coal vein in order to have room for men and mining machines to work. In this process the workers may breathe air containing silica, or sand, dust. The men wear masks to prevent their getting the disease known as *silicosis*. The equipment has water sprays to keep the silica dust out of the air the miners breathe.

Safety Education. Coal mining today is safer than ever before. Some of this improvement has resulted from the development of improved safety devices, but safety



Giant Coal Auger can bore a hole 52 inches wide and 280 feet deep almost as easily as a carpenter can bore a hole in a piece of wood with a brace and bit. The size of the auger may be compared to the men standing beside its engine.

Bituminous Coal Institute



Cutaway View of the Layout of a Typical Modern Underground Coal Mine
SHOWING THE ROADWAYS, SIDE PATHS, AND THE BLOCKS OF COAL

SURFACE MINING

More than one-fourth of America's coal is surface-mined. This is done where the beds of coal lie so near the surface they can be uncovered by removing the layers of earth which cover them. Giant shovels—often as much as ten stories high and with scoops nearly as large as city busses—clear away the surface strata. The exposed coal is then broken up and loaded into trucks by smaller mechanical shovels. At the preparation plant the trucks drive over dumping bins called "hoppers" and drop the coal onto a conveyor belt which takes it inside.

Come inside a coal mine . . . where America's strength begins!

Much of America's strength—and good living—begins in bituminous coal mines. Steel, electric power, heat, and thousands of everyday needs—from aspirin to paint—are made possible by coal. Coal is found beneath the earth's surface in beds averaging about 5½ feet thick, which often extend for many square miles. Layers of sandstone, limestone, clay, and shale usually cover the deep coal seams. Almost 75% of America's coal comes from underground mines. Miners are transported through tunnels from the mine entrance to the "working face." Mine operations require much planning, for a coal mine is a complex structure that must be laid out on blueprints and charted with care. Operating efficiency, safety, and terrain all play their parts in the planning of the mine.

The first step in removing coal is to make cuts in the coal bed across the bottom and sometimes vertically from top to bottom. A modern, electrically powered cutting machine is used **(A)**. Its steel teeth make a 6-inch-wide cut reaching 6 to 9 feet into the solid coal.

As coal is removed, and the mining area expands, roof supports are erected. Sometimes the roof is supported by wooden posts and "columns" of coal that are left in place. Often a new method is used, in which long metal bolts are inserted into the overhead layers of rock and slate to hold them securely together as a "roof" **(B)**.

The next step is power drilling **(C)**. Holes are bored in which to insert compressed air cartridges. These provide a safe, easily controlled explosive force, acting as a "pusher" to break the cut coal loose from the solid seam and tumble it into a pile of loose lumps.

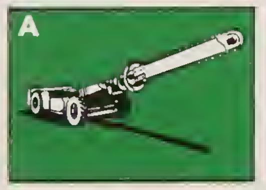
Each operation is performed with a safety inspector **(D)** constantly on the job. He checks the condition of the mine roof, tests the air for purity and rate of flow, and carries a special lamp that immediately detects the slightest trace of dangerous gas. He also sees that the roof and walls are regularly sprayed with powdered limestone to dilute the coal dust. This is called rock-dusting, and is done by special machines **(E)**.

With the coal loosened, mechanical loaders **(F)** scoop up the coal and feed it at the rate of several tons a minute into mine shuttle cars **(G)**, with a capacity of from two to ten tons. In many mines these cars deliver the coal to a moving conveyor belt **(H)**, which carries it to the cars of an underground railroad **(I)**. Sometimes the shuttle cars deliver the coal to the mine railroad directly. Powerful electric locomotives haul the loaded cars to a rotary dump **(J)**. The cars are picked up mechanically and turned completely over, dumping their contents onto the main conveyor belt, which carries the coal to the preparation plant on the surface. Here the coal is thoroughly washed; accurately sized; carefully blended; and laboratory tested. Today's coal is scientifically engineered to meet rigid burning specifications before being shipped to home and industry.

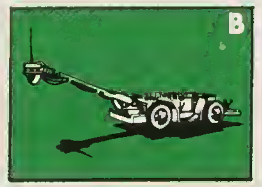
Aboveground, giant ventilating fans **(K)** carry fresh air throughout the mines and drive "used" air out, circulating six tons of air for every ton of coal removed.

All of these protections, plus an active safety education program under which miners and management meet to discuss problems, have made coal mining safer each year. Today mining coal is twice as safe as it was ten years ago.

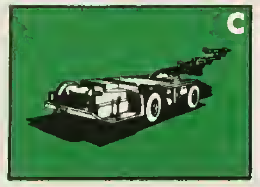
EDUCATIONAL SECTION
NATIONAL COAL ASSOCIATION
Southern Building • Washington 5, D. C.



Cutting Machine. A modern machine with a long bar that can be turned at any angle, and around which steel teeth revolve at high speed.

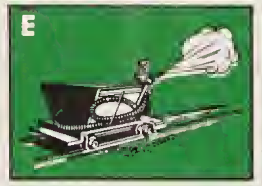


Roof Bolting Machine. This device drives strong steel bolts into the rock, slate, and shale above the coal, strengthening the roof to make it self-supporting.

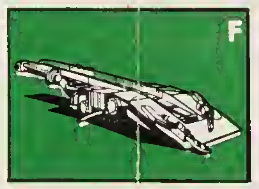


Drilling Machine. Mounted on a mobile carrier, the power drill, used to make holes for explosives, is almost as easily managed as a dentist's drill.

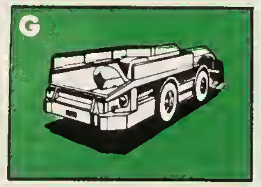
Safety Inspector. Because of the vigilance of these inspectors, and the importance given to safety measures, the bituminous coal industry has greatly reduced mine accidents.



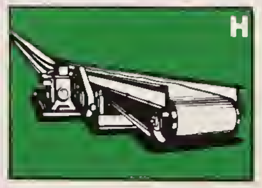
Rock Duster. This machine blows fine non-combustible limestone onto the mine walls and roofs, thus neutralizing any potential explosive force by inactivating the coal dust.



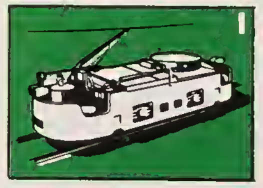
Mechanical Loader. So huge is this machine, and so fast does it work, that it can load up to six tons of coal each minute of its working day.



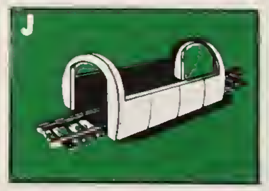
Mine Shuttle Car. These motorized vehicles operate independently, one or more to each loading machine, depending on the amount of coal being removed.



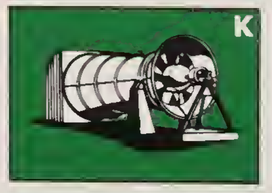
Conveyor Belt. These belts, made of tough, flexible rubber or stainless steel, carry coal at speeds from 300 to 700 feet a minute within the mine, and from the mine to the surface.



Underground Railroad. Though few outside the industry ever see this unique transportation system, American mines have more than 250,000 miles of underground tracks.



Rotary Dump. Saving many hours of labor, this ingenious device unloads an entire mine car as easily as a worker might unload a wheelbarrow.



Giant Ventilating Fans. These powerful fans supply air that is clean and fresh—by actual chemical test fresher than the air in the average city office.

Litho in U.S.A. 4-58

education has also played an important part. Many mines have a safety director who meets regularly with the mine foremen and with employee groups to discuss safety measures. A single violation of the no-smoking rule may cause a disastrous fire or explosion. The failure to put in roof timbers at a particular spot in the mine may cause a cave-in, trapping scores of miners. A good safety record therefore depends on the co-operation of the mine operator and the miners in carefully following all safety measures.

Many mines give safety drills for their miners at intervals, and provide "pep talks" on the necessity for no-smoking rules and various other measures to insure greater safety. Posters placed about the mine warn the workers of the possibly disastrous results if they do not follow safety regulations exactly.

The United States Bureau of Mines, founded in 1910, studies the hazards of mining and advises mine operators on measures to prevent accidents. As a result, deaths from explosions and certain other causes have been greatly reduced. The Departments of Mines in individual states have set up safety standards and regulations which also help to reduce the accident rate. Operators' associations and labor unions also aid in safety work and instruction of miners. Nearly all the disastrous mine accidents of recent years could have been prevented if safety regulations had been followed.

History of the Use of Coal

Early Use. The exact date of the first use of coal is not known. We have evidence that 3,000 to 4,000 years ago, in the Bronze Age, the people of Glamorganshire, Wales, used coal for funeral pyres to burn their dead. The Chinese probably used coal about 1,100 years before the Christian Era. This is especially interesting because China now uses very little of this important fuel, even though it has enormous coal resources. King Solomon was probably familiar with the coal deposits of Syria, for coal is mentioned in the Book of Proverbs (26:21). It is also referred to in several later books of the Bible.

The Greeks used coal several hundred years before the birth of Christ. Aristotle, the Greek philosopher, mentioned it in his writings. But hundreds of years passed before coal had any great and lasting influence on the course of civilization.

Use in England. During the Middle Ages in England, coal was commonly thought to be a curse. People thought it filled the air with dangerous poisons that injured people's health. In 1306, King Edward I of England issued a proclamation declaring the use of coal punishable by death. At least one man was put to death for breaking this law. In early days, the methods of burning coal were so inefficient that smoke and bad odor filled the air. Many people doubted that coal could ever be used successfully.

The word *coal* as used in the English language comes from the Anglo-Saxon *col*, which originally referred to charcoal. The spelling *cole* was used until about three hundred years ago, when the present spelling was adopted.

North America. Coal was discovered in North America in 1679. Father Louis Hennepin, a member of an early French exploring party, observed the black mineral along the Illinois River at a point about eighty miles southwest of the present city of Chicago. Some of the American Indian tribes, however, knew about coal long before this time. The Pueblo Indians of the Southwest used it in their pottery-making at an early date.

A colony of Huguenots, near what is now Richmond, Va., found a few pieces of bituminous coal near their colony in 1700. Fifty years later, a boy hunting crawfish discovered a rich bed in the region, and, before the end of 1750, mining operations were started. This was the first commercial mining of soft coal on the North American continent. In 1759, mining began in western Pennsylvania, and anthracite, now considered one of the finest of fuels, was discovered in eastern Pennsylvania in 1791. For a time this coal was believed to be useless. In some places the sale of anthracite was declared a fraud punishable by law. In 1862 Colonel George Shoemaker was arrested in Philadelphia for trying to sell a few wagonloads of it. But the value of this resource was soon recognized.

W.G.F. Critically reviewed by M.E.Sp.

Related Subjects. The reader is also referred to:

COAL PRODUCTS

Aniline
Aspirin
Benzene
Carbolic Acid
Carbon
Coal Gas
Coal Tar
Coke
Creosote
Dyes and Dyeing
Gas (fuel) (Coke Oven Gas; Carbureted Water Gas)
Illuminating Gas
Nylon
Perfume
Plastics
Synthetics
Toluene

UNCLASSIFIED

Diamond
Frick, Henry C.
Fuel
Hanna, "Mark"
Heating (Coal and Coke)
Hydrogenation
Industrial Revolution
Iron and Steel
Jet
Lewis, John L.
Mineral (color plate, Peacock Coal)
Mining
Peat
Power
Safety Lamp
Silicosis
United Mine Workers

Books for Young Readers

Cothren, Marion Benedict. *Buried Treasure; the Story of America's Coal.* Coward, 1945. Mining life as well as formation and history of coal.

Edelstadt, Vera. *Black Magic; the Story of Smoke.* Knopf, 1943. Coal from prehistoric swamps to present times.

Perry, Josephine. *Coal Industry.* Longmans, 1944. History, progress, and by-products.

Books for Older Readers

Ayres, Eugene, and Scarlott, C. A. *Energy Sources, the Wealth of the World.* McGraw, 1952.

Fawcett, Raymond, ed. *Where Does It Come from? Coal.* Heinman, 1952. Mining and vocational guidance.

Korson, George Gershon. *Coal Dust on the Fiddle; Songs and Stories of the Bituminous Industry.* Univ. of Pa. Press, 1943.

Mitchell, David Ray, ed. *Coal Preparation.* American Institute of Mining and Metallurgical Engineers, 1950. Handling coal before it reaches the consumer.

President's Materials Policy Commission. *Resources for Freedom: the Outlook for Energy.* U.S. Govt. Printing Office, 1952. Vol. III of a five-volume work.

Sheppard, Muriel E. *Cloud by Day; the Story of Coal and Coke and People.* Univ. of N.C. Press, 1947.

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II. How Coal Was Formed

- A. Time of Formation
- B. Coal Beds

III. Chief Kinds of Coal

- A. Anthracite
- B. Bituminous Coal
- C. Subbituminous Coal
- D. Other Kinds

IV. How Coal Is Mined

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    - 2. Drift mines
    - 3. Slope mines
    - 4. Strip mines
- B. Mining Systems
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    - 2. Longwall system
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    - 2. Cracking the coal wall
    - 3. Complete coal-mining machines
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V. How Coal Is Transported

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IX. Products from Coal

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- D. Unions
- E. Importance to Other Industries

XI. Mine Safety Measures

- A. Protection Against Gases
- B. Protection Against Coal-Dust Explosions
- C. Draining the Mine
- D. Protection Against Other Hazards
- E. Safety Education

XII. History of the Use of Coal

- A. Early Use
- B. Use in England
- C. North America

Questions

What is a tipple?

Why was coal not widely used until long after its discovery?

How and when is coal believed to have been formed?

How is coal used in the production of atomic energy?

What is a robot miner?

What, in order, are the four largest coal-mining countries of the world? The four leading coal-producing states of the Union?

How long may the coal resources of the United States be expected to last?

What is meant by "hard" coal? "Soft" coal? Where in the United States is anthracite found? For what is anthracite used?

What are the chief types of coal mines, and how do they differ?

What are the chief safety precautions which must be taken in coal mines?

How is carbon dioxide controlled in the modern coal mine?

About how much of the coal mined is wasted? How is this done, and what methods of conservation are being tried today?

What are some of the chief products of coal?

What is the principal means of transporting coal in the United States?

Where did French explorers first discover coal in North America?